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INTRODUCTION

The West at a Crossroads in Space: Quo Vadis?

It is an immutable fact that space has become an area of great strategic importance for the Western World. We rely upon satellites for communications, surveillance, navigation, reconnaissance, and scientific investigation. Yet, while all of these functions are important, it is nevertheless true that we have only "scratched the surface" of the enormous potential of outer space. Today, policymakers and private citizens alike are being obliged to consider and evaluate a plethora of proposals, programs and ideas for the development and intelligent use of space. In the scientific and commercial realm alone, these proposals are legion: a manned space station, space telescope, deep space probes, solar power satellite systems, space farms, space colonies, lunar colonies – the list goes on.

A far more pressing and important space issue, that of defense, was brought to light by President Ronald Reagan in his now famous address of March 23, 1983, in which he asked us all whether it would not be "better to save lives than to avenge them." After reflecting upon the question, the vast majority of the American people concluded that it would. They have come to realize that we presently have no defense against ballistic missiles, and that our security rests upon nothing more than a threat to retaliate against the Soviets if attacked – a threat which is becoming increasingly uncertain as the Soviets continue to build an ever-larger arsenal of offensive nuclear weapons. The prospect of using space for the purpose of truly defending the United States and its allies has excited much interest and, needless to say, a myriad of claims, assertions, charges and counter charges. Indeed, each of the proposals for military and non-military activities in space raises a number of important questions that need to be answered.

But how to answer them? We are now at a strategic crossroads in space, at a point where we must now decide upon the path we shall follow into space. "Which way?", then, becomes the overriding question of the day? Will we refrain from putting any types of weapons in space and abandon space commercialization as a lost cause, or will we have enough determination and vision to move boldly into the high frontier of space in order to

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ensure a bright and secure future for ourselves and our children? Put off by the arcane and often bewildering jargon associated with the debate over ballistic missile defense, many people come to feel that the issue is beyond them, that it is solely the province of scientists and politicans. This is not the case. The question of whether to undertake a program designed to free mankind from the brooding menace of nuclear destruction is one for all free people in a democratic polity to consider.

It is toward that end that this journal is dedicated; to summarize and encapsulate the many facets of the issue of exploiting outer space, and to put the issue into perspective for policymakers, academicians, and private citizens alike. Assembled herein are ten of the most cogent, insightful, and well-reasoned analyses ever written on the subject. The collection begins with Dr. Fred Iklé's pithy summary of the rationale behind President Reagan's Strategic Defense Initiative. Dr. Iklé's commentary serves as an excellent introduction to the collection, touching upon the essence of the SDI and some of the fake dogmas inherent in the morally bankrupt doctrine of Mutual Assured Destruction.

One of the many problems with MAD is that it is not really "mutual," since the Soviets have never accepted the doctrine of assured destruction. Indeed, they have continued to expand their offensive and defensive arsenals not only on the ground, but in space as well. The specific nature and impact of the Soviet space threat is spelled out very clearly in the article by Thomas Krebs. Drawing upon a vast pool of knowledge augmented by years of experience in this area, Krebs paints an alarming picture of the Soviet military effort in space, and makes a convincing argument for the strengthening of America's military capabilities in space to counter this threat.

Perhaps the most comprehensive and detailed analysis of the issue of strategic policy in the nuclear age written in the last several years is contained in Robert Bussard's contribution to this journal. Bussard artfully draws a parallel between our present predicament and that of our Founding Fathers, who risked everything — their possessions, their lives and their "sacred honor" — in the hope of radically altering the political and military realities of the day in order to ensure a brighter future for posterity. Bussard's analysis of MAD, our strategic vulnerability, and the need for effective defenses is nothing less than brilliant, and makes for extremely engrossing and informative reading.

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The brief piece which follows Bussard's is excerpted from the testimony of Lt. Gen. Daniel O. Graham, Director of Project High Frontier (perhaps the foremost proponent of strategic defense), before the Appropriations Committee of the House of Representatives. In his testimony, Graham managed not only to outline the High Frontier proposal, but to refute virtually all of the objections raised against it. His succinct yet thorough comments should inspire any reader to take a closer look at the High Frontier program.

One important issue not covered by Graham is that of the impact of an American ballistic missile defense system on the security of Western Europe. This issue, though, is amply addressed in the articles by Air Vice-Marshal Stewart Menaul and Janssen van Raay. Menaul correctly points out that arms control, as a vehicle for enhancing security, has failed NATO. Indeed, there has been a tendency in the Western democracies to place arms control on a co-equal basis with foreign policy and national security policy. This is a mistake. Arms control should be used as a tool, when needed, in the course of promulgating and enhancing national security policy. Pursuing arms control is pointless at best, and often counterproductive. As Menaul argues, the best way to guarantee the security of the Alliance is to reduce the utility of the weapons which form the basis of the threat to that security: Soviet ICBMs. Moreover, as van Raay states in his article, a defensive system is a much saner and more moral approach to security than is the large-scale use of nuclear weapons. And, as both authors contend, continued close cooperation and consultation between the members of the Alliance will ensure that whatever steps are taken serve the best interests of the organization as a whole.

The fact that ballistic missile defenses are feasible was made unequivocally clear on June 10, 1984, when the U.S. Army conducted a successful test of the Homing Overlay Experiment, in which a dummy ICBM warhead was intercepted and destroyed using the kinetic energy of a high speed impact, *not* nuclear detonations. Edwin Black provides an outstanding overview of the test and its implications for the future in his article, and he makes an eloquent appeal for a concerted national effort to deploy a defense that truly defends.

The security of the West does not depend solely upon its military capabilities, however. What is needed is a comprehensive strategy designed to address economic as well as military issues. As Bob Richardson points out in his article, the future of

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the free enterprise system (and therefore the future of Western economic stablity) lies in space. As the world's population grows, space will become a vital source of energy, food, and material resources, as well as a promising new environment for manufacturing materials and medicines that cannot be made on earth. An important prerequisite for private investment in space is security for that investment. In order to accomplish this, Richardson argues, we need to shift our strategy in a fundamental way. From Clausewitz and land power, to Mahan and sea power, to Mitchell and air power, security has been predicated upon effective strategy, and we are now in a position to adopt a space-oriented strategy, thereby realizing the security and economic benefits of space for the benefit of all mankind.

The immense benefits of space industrialization and exploitation are described in the entries by Peter Glaser and Robert F. Freitag. Glaser explains very clearly the rationale for an intensive development effort in space, and predicts that such development would yield enormous benefits to mankind. One step toward exploiting space effectively is the establishment of a permanent, manned space station. In his article on space station planning, Freitag makes a convincing, and even compelling, argument for a commitment to such a space station. He points out a number of economic dividends that a relatively modest investment in a space station would yield. Taken in concert, Glaser's and Freitag articles should convince even the most skeptical reader that commercial development in space is imperative.

In sum, the combined wisdom of these experts points to one incontrovertible conclusion: Space is the future. It is the future of our economic prosperity, our physical well-being, and our collective security. Man is capable of achieving some remarkable things and making tremendous advances if he is given the chance to do so. Empty promises about the deterrence inherent in Mutual Assured Destruction can do nothing to afford us that chance. What if deterrence fails, as it has done repeatedly throughout human history? The sad truth is that once a ballistic missile is launched, there is presently nothing our government can do to stop it. In the event of a Soviet strategic nuclear strike, it will be the average citizens who pay the price for the folly of the naysayers. And that price will be very, very high.

Strategic defenses are not a panacea: They cannot completely replace offensive capabilities, and we cannot expect them to

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help us create an insular "Fortress America." Strategic defenses can, however, play an important role in enhancing the security of ourselves and our allies. Their purpose is to defend, to save innocent lives in America, Europe, Japan, the Third World, and in the Soviet Union as well. We must make the difficult decisions necessary in order to strike a balance between our desire for peace and our commitment to defend ourselves, our allies, and our national values.

"Quo vadis" in space? Why, full speed ahead, of course, until we have secured the economic, social, and security benefits that a new environment has to offer, as our forefathers did some 200 years ago.

For, in the case of the development of space, it really is true that "the sky's the limit." We should not be afraid to tilt at the windmill of strategic defense. The naysayers tell us that doing so results only in being thrown into the mud. It can also hurl us up among the stars.

— Steven Adragna

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ARMS CONTROL AMNESIA

By Fred Iklé

Editor's Introduction

In a nationwide television address that startled the nation on March 23, 1983, President Reagan said in part:

> *"Let me share with you a vision of the future which offers hope. It is that we embark on a program to counter the awesome Soviet missile threat with measures that are defensive...What if free people could live secure in the knowledge that their security did not rest upon the threat of instant U.S. retaliation to deter a Soviet attack; that we could intercept and destroy strategic ballistic missiles before they reached our own soil or that of our allies?...*
>
> *"Would it not be better to save lives than to avenge them?...*
>
> *"My fellow Americans, tonight we are launching an effort which holds the promise of changing the course of human history. There will be risks, and results take time. But with your support I believe we can do it."*

Response to this address from the American public was powerful — and more positive, according to the White House, than to any previous Reagan speech. After 15 or more years of deep-seated and intensifying apprehension about the Soviet Union's huge buildup of nuclear weapons, many Americans had come to the alarming realization only in very recent months that they and their families have literally no defense against Soviet missiles once they are launched. Increasingly desperate to escape from this nuclear dilemma, they welcomed and heartily encouraged President Reagan's announced determination to mount an effective defense. Following are the remarks of Dr. Fred Iklé, U.S. Undersecretary of Defense for Policy, delivered at a Washington banquet commemorating President Reagan's so-called "star wars" address.

* * *

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A year ago today, President Reagan launched a renaissance in American thought on preserving peace in the nuclear age.

For far too long, some high priests of nuclear strategy have preached the policy of "mutual assured destruction." This "MAD" policy, which was crystallized in the Anti-Ballistic Missile Treaty of 1972, derives from the theory that, if both the United States and the USSR leave themselves and their civilian populations entirely undefended, neither will launch an attack on the other for fear of devastating retribution. Until recently, the advocates and authors of MAD have convinced themsleves and other policy-makers that MAD remains the most effective deterrence available, even though the Soviet arms buildup has been massive in recent years. This ideology, however, holds several false dogmas.

One of these dogmas has it that President Reagan's initiative on ballistic missile defense would overturn the principles of deterrence that have worked throughout the nuclear era. Not true. The ideologues must have amnesia.

— For the first five years of the nuclear era we had a nuclear monopoly; we did not have mutual deterrence through a threat of mutual destruction.

— For the next ten years of the nuclear era, we maintained extensive defenses to protect North America from Soviet attack. Again, we had not adopted a policy of mutual assured destruction, yet we had safe deterrence.

Only since the mid-1960s have the ideologues tried to make a virtue out of misery, arguing since the United States was becoming vulnerable to a Soviet missile attack, this was a good thing: assured destruction of the United States in the event of Soviet attack was said to be "stabilizing."

Another dogma of the ideologues who are opposed to missile defenses is that such defenses would hurt our alliances. Yet the President has made it clear that our allies will not be left out by his initiative. Why would it help the American guarantee to the alliance if the United States remained totally vulnerable to Soviet missile attack?

The third dogma of these ideologues is that missile defense will delay arms control. This is another manifestation of amnesia; The basic premise of fifteen years ago, which led to the treaty banning missile defenses, has been disproved. The premise was that such defense would permit us to curb the growth of offensive arms. But after the ABM treaty was signed, the

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Soviet offensive build-up continued its exuberant pace.

In the nearly 15 years since the negotiations on the ABM treaty began, the Soviets have added some 7900 medium and long-range nuclear missile warheads to their arsenal – an increase of 515 percent. This is arms control? Since the SALT II agreement was signed in 1979, some 3850 Soviet warheads were added, a growth of almost 65 percent. What is so valuable about this so-called "arms control process" that must be preserved by making the ABM treaty forever untouchable?

The inconsistency of our ideologues is nowhere more apparent than in their position on other arms control issues. They applaud the Biological Weapons Convention, for example, because it prohibits *offensive* use of biological agents. Defenses are clearly permitted. (All of us are against offensive biological weapons, except, apparently, some of the Soviet military.) Second, these ideologues oppose *offensive* chemical weapons, while supporting *defensive* chemical warfare equipment. But third, they turn their own rules upside down for nuclear arms by arguing that, here, defenses are bad.

A curious aspect of the ideology against missile defenses is the notion that outer space must be reserved for offensive missiles, so that they can travel without obstruction to create holocaust on earth. The ideology demands a sanctuary in outer space that excludes any protection for the cities we live in, but offers a free ride for the missiles that could destroy our cities.

Fortunately, while the ideologies are confused, the American people are not. They are more pragmatic (*see Editor's Note below*). Yet, there are some members of Congress who want to preserve outer space as a freeway for Soviet missiles to fly through and hit American cities, without obstacle and opposition. I believe the voters will find a way to explain to these members of Congress that most of their constituents do live in these cities – only a few voters live in outer space. I believe five hundred thirty-five members of Congress represent constituents who want to have defense and protection on earth rather than to preserve outer space as a freeway for missile attacks.

The President's speech a year ago has removed doctrinal blinders that have hemmed in American strategic thinking. The President has toppled an ideology that has become increasingly contrary to fact and common sense.

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The renaissance in our thought that President Reagan has ushered in provides new opportunities to overcome the deadly interlock of hostile missile forces; it opens new, more creative approaches to arms control; it opens the doors to escape from the constant threat of mutual genocide.

There is evidence to suggest that over time the Soviet Union will become receptive to such a new approach that will provide an escape from the deadly nuclear confrontation with its ever present doomsday threat. You can be sure that the people of the Soviet Union also wish to escape from the present nightmare of huge and unimpeded missile forces, constantly poised for mass destruction.

As the President explained, the task is formidable. And we in the Defense Department are well aware of the enormous technical challenge and the many complexities.

But I am confident that we can count on the good sense of the American people to reject the permanent nightmare, and to support Presidents Reagan's vision for a better future.

* * *

Editor's Note:

A nationwide professional sampling of public opinion, done by the well-known firm of Penn & Schoen for the Committee on the Present Danger and released in April, 1984, found that most Americans view the nuclear freeze as "a way to reduce the expense of nuclear arms" rather than as a measure that would reduce the threat of nuclear war. Most Americans in large majority also favor development of space-based defensive weaponry, with or without a nuclear freeze.

Among the poll's findings are these:

– While 64% favor the concept of a nuclear freeze, 63% oppose a unilateral freeze, believing it would threaten U.S. security.

– 63% believe the Soviets are using the nuclear freeze issue "to try to gain a permanent advantage over the United States."

– By a greater than five-to-one margin, Americans believe that the Soviet Union is violating existing nuclear arms control agreements.

– Three out of four Americans support the development of space-based "defensive weapons."

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— Two out of three Americans oppose telling the Soviets "that we will not respond with nuclear weapons if they attack our allies."

— 63% favor American retaliation in the event of a Soviet attack on the United States "even though it may result in total destruction of both countries."

— 70% express confidence in the government "to make the right decisions" regarding American security.

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ASSURED MUTUAL SURVIVAL: THE ABM SOLUTION

By Brigadier General Edwin F. Black

On June 10, 1984, the U.S. Army achieved the world's first interception of an incoming ballistic missile warhead by a non-nuclear ABM more than 100 miles above the Western Pacific Ocean. This happened in peacetime, less than 15 months after President Reagan made his historic speech of March 23, 1983, calling on "the scientific community in our country, those who gave us nuclear weapons, to turn their great talents now the the cause of peace; to give us the means of rendering these nuclear weapons impotent and obsolete."

During debate on the FY 1985 defense authorization bill on June 12, 1984, the full Senate in closed session received a three-hour secret briefing on the comparative status of U.S. and Soviet research on ABM and anti-satellite weapons. The briefing emphasized the dangerous strategic consequences which would result if the U.S.S.R. succeeded in deploying an effective ABM defense ahead of the United States and its allies.

The successful Army test discredits the "can't do" arguments put forward by such organizations as the Union of Concerned Scientists and their well-known spokesmen, Drs. Hans Bethe and Wolfgang Panofsky. It also proves how wrong the lead editorial in *The New York Times* of March 27, 1983, was when it called the president's speech "a pipe dream, a projection of fantasy into policy."

In fact, in that speech the president announced the most important political/strategic decision since the beginning of the nuclear age. He told the world that America's national security policies would no longer rely on deterrence based on the immoral concept of mutual assured destruction (MAD). Instead, we would work toward a condition of mutual assured survival for the United States and its allies.

The significance of the president's decision is that it changes the basis of deterrence from a purely offensively oriented strategy, appropriately called MAD, to a balanced strategy containing both offensive and defensive components. It looks

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forward to the day when whole populations will not have to be pledged as defenseless hostages to nuclear annihilation to maintain the present irrational "balance of terror."

We have begun the transition to a new period of international relations. As ballistic missile defenses become more and more effective:

- The structure of national defense establishments throughout the world will change.
- Space will become a vital component of national security.
- Defense systems involving the new dimension, space, will necessarily have to be regional in scope. This will strengthen alliances and emphasize the reality of interdependence.
- As the utility of ballistic missiles declines, new opportunities for arms control will emerge. Disarmament negotiations, no longer hampered by the insatiable demands of MAD, can take advantage of mutually beneficial phased tradeoffs between offensive and defensive strategic systems.
- Stability will be enhanced, as the two superpowers find it possible to move away from the perilous "launch on warning" readiness posture they both have been forced to assume under the MAD concept.

America is now fully committed to the strategy of mutual assured survival. Research on ABM defense has been assigned top priority within the administration. The two principal objections — that the concept is not technologically feasible, and that even if it were, it would be destabilizing — have been addressed and resolved.

After five months of study, the skeptical Fletcher Commission, made up of some of our finest scientists, concluded that "defensive technologies are available which provide a sound basis for designing an effective layered-defense system against ballistic missiles." During the same period, a second commission, which included highly respected authorities on strategy and international relations, concluded that the establishment of such a system would "significantly enhance deterrence and world stability."

Funds of $2 billion have been allocated in the FY 1985 budget as the initial increment of a five-year, $26 billion program of research on the most promising ABM technologies.

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A single project manager, Lt. Gen. Abrahamson, who was formerly in charge of the space shuttle program in NASA, has been appointed. He reports directly to the secretary of defense who in turn keeps the president informed of any bottlenecks or other obstacles which might require his personal intervention to resolve.

Nationwide opinion polls show that three out of four Americans support the president's strategic defense initiative, the concept of mutual assured survival and its related ABM and space-based defensive systems.

The test itself validated the wisdom of ongoing research in kinetic energy and demonstrated the very considerable progress that has already been made in long-wavelength infrared sensors and optical homing technology.

While not yet in the headlines, encouraging progress is also being made in another area of ABM research: directed energy technologies. Significant advances have been made in the design of compact, lightweight and relatively inexpensive X-ray laser accelerators. At the time, the dedicated scientists at the national nuclear laboratories – Sandia, Los Alamos and the Lawrence Livermore Lab – are quietly working hard to solve the problems of neutron and charged particle beams.

Of course the Soviets, too, are working quietly and diligently behind their traditional wall of secrecy. The U.S. Intelligence community, together with the Joint Chiefs of Staff and our NATO allies, are all deeply concerned with the magnitude and sophistication of the Russian ABM programs – programs which were started as long ago as 1967. A January 1984 CIA report provides evidence that the Soviet Union is making an all-out effort to develop a nationwide missile defense system built around the most modern laser and particle-beam technology.

Now that mutual assured destruction is being replaced by mutual assured survival as the basis for national security, the ABM Treaty has become "overtaken by events." Accumulating evidence of Soviet violations of its letter and intent indicate it may only be a matter of time before they abrogate the treaty and begin deploying their ABM defenses. We are in a race which we cannot afford to lose.

NOTE: This is an abridged version of an article which appeared in the "Commentary Section" of *The Washington Times* (June 22, 1984).

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THE SOVIET SPACE THREAT

By Thomas H. Krebs

Introduction

For most Americans, the "space race" is a memory tucked away in recesses of their minds. If recalled at all, the memory evokes images of our national pride and pleasure in a peaceful race that was run well and won decisively. Until recently, this attitude was reflected within inner government circles as well. Intelligence resources applied to the Soviet space program peaked in 1969, the year American astronauts planted a colorful U.S. flag on the surface of the moon. The Soviets tried and failed three times to get their mammoth, many-engined moon rocket to lift a payload into orbit. After their last failure, they turned their attention away from the moon, and U.S. intelligence agencies turned their attention away from the Soviet space program. Unfortunately, the new Soviet space efforts had considerably more far-reaching and menacing objectives than landings on the moon.

Fortunately, the United States Government, in recent years, has made a major, renewed effort to focus on the capabilities and intentions of the Soviets with respect to space. Some of their findings are now declassified and thus available to the American people. Much of the factual material in this article is a result of this declassification.

In 1965, in a publication, *Military Thought,* intended for the widest possible distribution within the Soviet military officer corps, the General Staff outlined their Space Doctrine. It was "a doctrine envisaging active hostilities in space and regarding the mastery of space as a prerequisite for achieving victory in war." The Doctrine's implications are clear: Domination of space, the ultimate high ground, can prevent access to and use of space by other powers during wartime. If the objectives of this doctrine are ever achieved, the probability of Soviet success in terrestrial battles would be greatly enhanced. For the West, the credibility of our conventional deterrent would be severely lowered.

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The Industrial Base

The Soviet doctrine, set at the highest levels of government, was accompanied by a comprehensive plan and the long-term commitment of resources adequate to bring it to fruition. Although the U.S. space program relies on infrequent but revolutionary improvements in space capabilities, the Soviets have been steadily reaching toward their goal with small but frequent evolutionary steps. The competition is analogous to the fable of the tortoise and the hare. Vast funds have been plowed into the Soviets' space program – an average of about $10 billion per year from 1973 through 1979, not counting considerable launch and operational costs. Since then, expenditures have taken off like the rockets they have funded.

- In 1983, Soviet spending on space was $21 billion, not counting the costs of launching and operating its satellites. U.S. spending was $15-$18 billion, including launch and operation costs.
- Although both countries maintain about 120 satellites in orbit on a daily basis, the Soviets launch about six times as many satellites each year as does the U.S.
- The payload launch each year by the Soviets is about 10 times greater than for the U.S.

The major reason why the Soviet Union has about the same number of satellites in orbit as the U.S. does, despite its much higher launch rate, is that Soviet satellites have a much shorter life span. This is due to the fact that about half of the Soviet satellites launched each year are military surveillance satellites. These satellites cease to be useful when they run out of film, usually after only a few weeks in orbit.

The entire Soviet space effort is far more oriented toward military goals than that of the U.S.

- About 90 percent of all Soviet satellites are estimated to have a military purpose.
- By constrast, only 30 percent of all U.S. spending on space activities has a military purpose.

"Soviet Military Power – 1984," published recently by the Defense Department has this to say about Soviet spending on space:

> "By all measures, the Soviet level of effort devoted to space in the 1980s is increasing significantly over the activities noted in the 1970s. The projected yearly rate of

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growth of the Soviet space program is expected to outpace both the annual rate of growth in overall Soviet military spending and that of the Soviet gross national product for a number of years to come."

This statement may even be conservative. If the growth in outlays continues the pattern established over the last four years, Soviet spending on space activities in the next ten years would increase to approximately $55 billion annually, or an amount about equal to what they spend for their Strategic Rocket Forces, or their Ground Forces or their Navy. That expenditure rate would be reasonable only if the Soviets considered the mastery of space to be a "prerequisite for achieving victory in war."

Part of the preparation for mastery of space is the building of a comprehensive logistics support base. The Soviets have three extensive assembly and launch complexes at Plesetsk, Kapustin Yar, and Tyuratam. The important military value of these complexes is underscored by the fact that each is surrounded by air-defense networks, including surface-to-air missiles and manned interceptor bases. One of the complexes also may be protected by a ground based high energy laser site. These complexes have, over the years, launched 14 different types of spacecraft launch vehicles, over half of which are still in use. By contrast, the U.S. relies extensively on only one type of launch vehicle, the Space Shuttle. The U.S. Air Force is considering bids from industry and NASA to develop and produce two expendable launch vehicles per year of a new type. This is being done to provide insurance against the possibility that the Shuttle fleet of only four orbiters might be grounded for technical difficulties or plagued with airborne mishaps that can occur in any new aerospace development.

The Soviets also have more than 3,200 research institutes for scientific and technological progress. Many of these support the military in its space, aircraft, naval, and ground force developments. These institutes have experienced a 30 percent growth in the last 10 years. Such large scale commitment to research and development must be accompanied by trained personnel. Those who remember the large push in the U.S. to increase the number of our country's technical graduates after the launching of the Sputnik in 1957 might be surprised to find that today the U.S. graduates only about 100,000 scientists and engineers each year while the Soviet Union graduates 500,000. More

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fully 900,000 Soviet scientists and engineers are in research and development – making the Soviet R&D force the largest in the world.

Much of this large technical base has been used to give the Soviet Union its superpower status with its emphasis on military weapons systems developments and deployments. Although the largest military payoffs in space from this R&D effort are yet to come, the Soviet space program already poses a significant military threat to U.S. and NATO forces.

TODAY'S SOVIET SPACE WARFARE THREAT

Weapons Systems

The United States' space assets have become vital not only to our peacetime endeavors but to our wartime endeavors as well. The Soviets' ability to threaten those assets decreases our conventional deterrent to war. In low earth orbit the U.S. has, for example, reconnaissance, weather and navigation satellites. All would be relied on heavily in the event of a war. The Soviets have an even more impressive list of satellites in low earth orbit including one series that is nuclear-powered and that can find and relay data sufficient to target U.S. surface ships in oceans around the world. This system is known as the Radar Ocean Reconnaissance Satellite (RORSAT) system. One of these 5½-ton satellites scattered nuclear debris across Canada in a fiery re-entry into the atmosphere in 1978.

"Killer Satellites." Although the U.S. is planning, against stiff political opposition, to have an anti-satellite (ASAT) capability against low orbiting Soviet satellites by the end of the decade, the Soviets already have achieved that milestone several times over. In fact, they began testing a co-orbital ASAT in space shortly after their 1965 space doctrine went out to the troops. By 1971, according to the U.S. Defense Intelligence Agency, the Soviet ASAT system had achieved operational status. It is a system which uses kinetic energy (high velocity impact) for its kill mechanism. Basically, it makes a rendezvous with its target within 90 to 180 minutes after being launched from one of two launch sites at the Tyuratam space launch complex, and fires an explosive shotgun-like charge at its target. In tests to date, its effectiveness has been nearly equal to the requirements for the U.S. system still under development – and

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it has been in their operational inventory for 13 years! According to "Soviet Military Power – 1984," the two launch sites at Tyuratam ought to be able to support at least six launches per day. This means that if there are about two dozen important U.S. and NATO satellites orbiting within 3,000 miles of earth, the Soviets should be able to knock them all out handily within a week, even accounting for evasive maneuvers by some of our satellites and for unreliable ASATs. Though no one knows how many ASATs the Soviets might possess, about 40 to 50 should do the trick, and the Soviets have had 13 years to build up an inventory of ASATs and boosters. Since they routinely launch about 100 space boosters per year, an adequate inventory should be assumed.

Ground-Based Lasers. In addition to the co-orbital ASAT system, the Soviets have been hard at work developing laser technology.

- The Soviets spend three to five times more than the U.S. on laser technology, and many experts rate them as being ahead of the U.S. in this field.
- The Soviets have two ground-based test lasers with the capability to destroy satellites in low earth orbit and damage sensitive systems in satellites all the way up to 20,000 miles above the earth.

Although these are R&D systems which do not have 24-hour-per-day, high-reliability operational capabilities, they still pose a current threat to our vital military satellites. Because of the geometry of motion of both the earth and the low orbiting satellites, each of the U.S. satellites can be expected to pass a Soviet laser facility at least twice per day and, depending on the range of the laser weapon, up to four to six times per day. This means that the Soviet lasers theoretrically should be able to destroy all U.S. low earth orbiting satellites in less than 12 hours. If one takes into account that it would be difficult to fire a laser beam through adverse weather, and given some degree of unreliability in the "test" systems, then a conservative estimate of two or three days should be sufficient to do the job. This is a considerable recent improvement in Soviet capability over the co-orbital ASAT system discussed above.

Electronic Warfare. The Soviets have other means to render our wartime support capability from satellites less than credible. They have the technological capability of conducting elecronic warfare against our satellites regardless of altitude. Electronic

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Warfare (EW) is a favorite technique of the Soviets in areas other than space, and it is reasonable to presume that they would use it against our satellites perhaps even more readily than they would use the more directly provocative means noted above. Although EW techniques are numerous and some highly technical, their effects are similar to running a vacuum cleaner in the same room as a cheap TV set — the picture goes haywire until the vacuum cleaner is turned off. Satellites gathering information with sensitive electronic "ears" cocked towards an area of political tension or actual combat would be particularly susceptible to such temporary yet effective interference.

Anti-ballistic Missiles. Although this form of ASAT threat is unlikely to be used, the Soviets also possess the capability to destroy satellites in space using the nuclear warheads on their Galosh anti-ballistic missile system which rings Moscow. The likelihood of this is low, however, because of the high effectiveness of the system already mentioned, the fact that use of nuclear weapons in such a limited manner might easily escalate, and because these weapons are, after all, in place to protect Moscow and its vast interlocking grid of ministries and technocrats.

Those in the U.S. who suggest that the U.S. ASAT program under development will militarize space should take a look at what the Soviets already have done. There are no U.S. counterparts of their ship-finding and targeting nuclear RORSATs, their co-orbital ASATs, their two ground-based laser ASATs, or their nuclear-tipped anti-ballistic missile system. They appear already to have achieved their objective of domination of space, at least in the lower reaches of that environment.

Support Systems

In addition to their ASAT and RORSAT programs, the Soviets have more than 40 other types of satellites in orbit on any given day. They typically have about 55 communication satellites for various military, governmental, diplomatic, intelligence, and civilian uses in orbits ranging from very low up to 20,000 miles above the earth. This communications system, as extensive as it is, has not been allowed to become an Achilles heel, as in the West. Though not cost effective, the Soviets have maintained redundant ground communications

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capabilities to guard against catastrophic losses in wartime. By contrast, it has been estimated that 75 percent of all Western long distance communications traffic goes via satellite. This traffic cannot be accommodated by existing ground communications networks.

The Soviets also operate about 24 meteorological and navigation satellites. Although these have obvious peacetime uses, their wartime utility is enormous. Access to accurate and timely weather forecasts is a prerequisite to success of conventional warfare in modern military engagements. It also can be used to improve the accuracy of ICBM and submarine-launched missile warheads through estimates of how weather conditions in the target area may affect reentry vehicle motions and therefore its accuracy in the final seconds before impact. Navigation satellites can be used by military aircraft and they can improve the accuracy of submarine launched ballistic missiles by pinpointing the location of the submarine.

Manned Systems

The Soviet manned program far exceeds the activity level of the U.S. program. The Soviets have conducted many manned missions aboard their seven consecutive space stations, three of the mannings being for periods longer than six months. One lasted 211 days – about three times longer than the longest U.S. manned mission. That U.S. mission was aboard Skylab, the only space station we put up and which reentered the atmosphere about five years ago. The next U.S. space station will not go up for about a decade, according to the President's State of the Union address in January 1984. Currently the Soviets have their seventh manned space station in orbit. It is visited on a routine basis by the Soyuz spacecraft bringing visitors, special instructions, and additional mission experiments. They also have deveoloped a Progress spacecraft similar to the Soyuz which is unmanned and which docks to the Salyut space station in an automatic manner even when Cosmonauts are not aboard. It transfers fuel, new experiments, and supplies. A space station module as massive as the station itself has from time to time been launched into orbit and then has attached itself to the station. Articles in defense publications suggest it has a military mission and may have tested the components of a kinetic energy system that eventually could be used as part of an anti-ballistic missile network.

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When the Salyut, the Progress or the Soyuz spacecraft and the space station module are all attached, the complex is about 100 feet long. Yet this station will be dwarfed in size by a future complex to be discussed later. Part of the justification for the U.S. space station now undergoing conceptual design studies is to use it as a scientific and industrial test bed — an activity the Soviets have been gaining experience on since their first station went into orbit in 1971. Their space station also offers them the opportunity to test military subsystems of future satellites in a benign environment. This allows them to avoid having to build complete space-qualified hardware to test new sensor techniques for reconnaissance satellites, for example.

Reconnaissance and Surveillance

Between 20 and 30 types of satellites fall into the category of reconnaissance and surveillance. These satellites have extremely high direct wartime usefulness. Soviet photographic and electronic reconnaissance satellites were first launched in the early 1960s. They now put up about 50 per year, which account for the largest single group of each year's launches. Most of these satellites last for only a couple of weeks and then reenter after their film supply is exhausted.

These satellites are used in a variety of ways. They make accurate maps, essential for planning military campaigns, including maps for client states. They are used to keep an up-to-date record of where new, movable or moving enemy targets (such as ships, submarines, or aircraft that emit communications or radar signals) are located. They keep track of military force deployments around the globe, an activity which is especially useful in the midst of crises. In addition, the status of new weapon system developments can be monitored by combining the capability of overhead electronic and photographic systems. Other electronic eyes in high orbit keep in constant touch with Moscow while staring at U.S. ICBM sites to provide the primary means of early warning of a nuclear attack.

Launch Surge

Possibly one of the greatest space-related Soviet advantages is their ability to flood the skies with additional satellites prior

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to the outbreak of a major conflict. The U.S. must plan its space lauches years in advance. With a limited number of launch pads and orbiters, our ability to respond to crises by space launches is severely limited. The Soviets, on the other hand, could possibly double the number of spacecraft in orbit given a few months warning as in a period of steeply rising tensions or in an actual conflict. This asymmetry will persist. Note that the U.S. ASAT program is having trouble in Congress getting appropriations for only 40 ASAT missiles — hardly enough to take out vital Soviet military satellites in low earth orbit in the face of a determined Soviet launch surge.

A Mid-1980s Warfare Scenario

Assume for the sake of example that geopolitical tensions are rising and that the Soviets come to the conclusion that hostilities between the major powers are probable though not certain. What actions concerning space would be likely to be taken? It is probable that the Soviet average of 120 satellites in orbit is a number that is somewhere between peacetime and wartime requirements. If war were to occur, the Soviets could not count on having the luxury of launching satellites day after day. They would know that in certain circumstances that activity could be curtailed by their adversaries. They most likely would initiate a pre-war buildup of satellite systems from a carefully built reserve of satellites and boosters stored in facilities near the main launch complexes. Also, wartime requirements most likely would exceed what the Soviets in peacetime consider a full satellite network, since they would want to provide backup satellites in orbit to make up for failed systems or satellites destroyed accidently.

Primary among the systems to be augmented would be their ICBM launch detection system. It also is likely that they would augment the crew, equipment and supplies of the Salyut space station to provide round-the-clock manned reconnaissance. They probably would start to launch protoreconnaissance satellites with increasing frequency to provide more timely information on military force movements and to provide for in-orbit spares if the war were to start. If the conflict were to go nuclear, most data bases would be destroyed and those that remained would be out of date due to the widespread destruction. Therefore, the value of correct information would go up

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by several orders of magnitude, and the need for post nuclear attack photoreconnaissance would be greater. Electronic surveillance satellite systems also would be augmented for some of the same reasons. Satellites capable of targeting surface fleets probably would undergo the greatest augmentations, because these are quite expensive to keep up in peacetime and because the value of accurate wartime information on the locations of our 10 to 12 carrier task forces would be nearly priceless to the Soviets. Their communications networks also would be augmented as much as possible, although satellites in geosynchronous orbit require them to use large and slow-to-launch boosters. All of these steps could be carried out before actual hostilities occur, assuming there is enough time – way, six to ten weeks. All of these systems would help the Soviets prepare for war, should one occur.

Let us assume that tensions rise to the point of invasion by the Soviets on the NATO front. Several days before this, we could expect to see electronic warfare measures being used against Western satellites in order to prevent them from gathering information about critical pre-invasion actions. Coincident with the invasion itself, we could expect to see the first physical attacks of the war against Western space assets by Soviet ground-based lasers and co-orbital ASAT interceptors. Within days, all U.S. and NATO low earth orbit satellites would be out of commission with little hope of replacing them. As bad as this scenario sounds for the U.S., it is certain to get much worse in the coming decade.

Tomorrow's Space Warfare Threat

The recent large spurt in Soviet space program spending will start to yield benefits within a couple of years. These benefits will be maximized before the middle of the next decade. An enormous increase in warfighting capability in space is forecast, as well as a concurrent increase in capability to assist, directly or indirectly, ground, sea and air forces of the Warsaw Pact. All of the developments described below are probable by 1994 or earlier. Unless the U.S. does something it is not now planning to do, and does it fast, sometime in the next decade the Soviets will have achieved their objective of mastery of space all the way out to geosynchronous orbit – that special environment where the speed of the satellite revolving around the earth exactly

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matches the speed of the earth's rotation which results in the satellite appearing to remain suspended above a single spot on the equator.

THE NEXT TEN YEARS

Launch Systems

Key to the expected expansion of their space program is the concurrent development of three new Soviet space launch boosters. Whereas the U.S. built its magnificent Space Shuttle at a cost of over $7 billion after years of conceptual and engineering development studies and tests, the Soviets have chosen a much cheaper and quicker way to achieve the same capability — they merely copied, then improved upon our design. NASA designs were available to anyone who wanted them and apparently the Soviets acquired copies. Their decision saved them billions of dollars and will nearly double the payload they can place into low earth orbit per flight. But the Soviet designers were not content to merely copy this advanced system. They moved the liquid oxygen/liquid hydrogen engines from the orbiter to the bottom of what would be the external tank next to the orbiter's underbelly in the U.S. design. This gives then not an external tank, but a huge booster on its own. Some U.S. Shuttle engineers have been heard to say, "Wish we had done that in the beginning."

According to cost extimates in preliminary studies, it would cost the U.S. about another $7 billion to duplicate the performance advantage of the design that the Soviets essentially got for free. The new booster, when used with up to six much smaller strap-on boosters (but without an orbiter attached) will be able to boost at least 330,000 lbs. of payload into low earth orbit. This is five times the payload carrying capability of the orbiter itself. If the Soviets choose to add another stage, they will have the capability to place up to 100,000 lbs. of payload into geosynchronous orbit. To get an idea of just how much weight this is, consider NASA's plans to enlarge the Centaur upper state and to fit it to go into the Space Shuttle cargo bay. When that is accomplished, we will have the capability to put up about 10,000 lbs. into geosychronous orbit, roughtly 1/10 of the new Soviet capability. The military potential of placing such exceptionally high weights into low or high orbits will be discussed below.

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It appears that the small strap-on boosters for the large booster are in the size range to meet the requirements for a third stand-alone booster to be used in the Soviets' new space launch vehicle fleet. Though this one would be able to put up only 33,000 lbs. — less than their best booster to date — it would provide them greater flexibility and may possess other advantages as well. All of these boosters should be ready for flight test within the next year or two .

In addition to the three new boosters, the Soviets are expected to develop within this decade a space tug. This vehicle would provide orbit-to-orbit transfer for satellites and manned vehicles similar to the way small twin engine propeller aircraft provide local air service at international airports after huge Boeing 747s disgorge their passengers. (The space tug, incidently, is something the U.S. Air Force and NASA originally had planned to build as part of our Shuttle program but were unable to for lack of money, among other reasons.) These new Soviet booster developments probably will be added to their already impressive number of space launch boosters and will enable the Soviets to significantly increase their space program in terms of the number of satellites in orbit as well as the size, weight, and orbital location of those satellites.

Support Systems

Within the next decade, the Soviets are expected to deploy advanced communications, navigation and meteorological satellites which will offer them greatly increased wartime capabilities. All of these new capabilities are ones which the U.S. already has. But, when coupled with weapons systems which the U.S. does not have and does not intend to build, these capabilities will offer the Soviets singular advantages. In the communications area, it is expected that the Soviets will put up satellites capable of relaying data from or to other satellites. Because of the utility of such a system, and because its technology is readily available in the West, these satellites probably will have the ability to track and command other satellites, as in the NASA Tracking and Data Relay Satellite system. In the navigation area, it is very likely the Soviets will follow the lead of the U.S. in deploying satellites with the ability to let even fast-moving aircraft know their location instantaneously in three dimensions. This has obvious implications for the ability

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of tactical aircraft to hit ground targets with extreme accuracy, even at night or in bad weather.

Reconnaissance and Surveillance

According to "Soviet Military Power – 1984," the next decade will bring unspecified improvements in Soviet missile launch and warning systems as well as in their photographic and electronic reconnaissance systems. If they are able to marry the ability to transfer signals from satellite to satellite (noted above under communications satellites) with advanced sensors, it is conceivable that they could have a reconnaissance system that would work electronically instead of using film as a base. This would give them the capability to send pictures back to an intelligence center or to a battlefield command post with little time delay after the satellite passed over the area of interest.

Manned Systems

It is in the area of manned systems that some of the most dramatic and controversial projects are being developed by the Soviets. These will either turn out to be colossal duds or extremely effective military assets. The reason for the controversy, at least in this country, is that the U.S. Defense Department has for some time now taken a dim view of military requirements for manned systems in space. For example, it is public knowledge that the Department actively opposed the plans to build a permanent U.S. space station which is now scheduled to go up between 1992 and 1994. The prevailing, though far from universal, attitude in U.S. military circles has been that there are easier and cheaper ways of doing the same missions in space. In general, these ways would focus on unmanned spacecraft.

Many of these same people routinely approve manned ships, manned tanks, manned aircraft, manned submarines, etc. Why is there such a difference in attitude when it comes to the space enrivonment? Perhaps it boils down to how the environment of space is perceived in its relation to military missions. For many years the U.S. looked upon space as a scientific laboratory, a research and development resource, or as a place to put equipment to help air, sea and ground military forces do their jobs. The Soviets, on the other hand, appear to see space as just

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another warfare environment, as their 1965 space doctrine indicates. In the Soviet view, if one is placing systems in a warfare environment it is natural to build a number of weapons systems to control that environment.

Putting a human being on board adds an additional element of control. For example, if space is a peacetime environment only, we can predict what extremes of temperature, radiation and pressure satellites will encounter and we can safely design a system to meet the challenges of the environment. However, if space is a wartime environment, the satellite might be subjected to any number and variety of military threats from any direction. Man is needed to be able to respond to these unanticipated challenges that face the space system. These same kinds of unforeseen occurrences also will be happening down below. Perhaps well-trained and equipped military men in space might be able to influence the outcome of a battle far below the spacecraft. With this discussion as a background, we will turn to just what it is that the Soviets are planning to do with manned systems in space in the next decade.

Since 1982, the Soviets have been testing a small space plane that is either capable of being manned or is a scale model of a large manned space plane. Missions for this craft are unknown but the following suggest themselves. Such a system can be used as a ferry craft between manned space stations or as a rescue vehicle. More ominously, fitted with external fuel tanks from a large space station, a space plane could be used to inspect another nation's satellites and destroy those satellites using small onboard rockets. The orbital reach in the latter example would be almost unlimited, and would include geosynchronous orbit. It also could be used as a quick response reconnaissance vehicle to take a look at enemy forces during wartime. Since the space plane, to date, has landed in water on its test flights, a similar naval mission can be postulated. Suppose a Soviet Radar Ocean Reconnaissance Satellite revealed the location of a large naval task force spread out over a 100-mile wide area but the location of its most important elements, such as its carrier or cruiser, were not known. A solution: a fast response space plane is launched and timed to pass over the area of interest in the first revolution around the earth and then re-enter into the ocean near a Soviet naval task force possessing the means to destroy the U.S. force.

The Soviets also are planning, within two to three years, to

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enlarge their present space station (which normally holds three cosmonauts and occasionally five to six), to one which can accommodate up to 12 cosmonauts. This will put it in the class with the U.S. plans for its next space station. But the Soviets also are expected to build a considerably larger station, weighing perhaps a million pounds or more, which will accommodate up to 100 cosmonauts on a permanent, though rotating basis. It is this large-sized station, expected in the early-to-mid-1990s, which has some military planners worried. What can 100 highly skilled men do in space? Consider that in nuclear crises the U.S. vests backup control of all our nuclear forces in an aircraft holding a crew of only 20 highly skilled men. Though it would certainly be a backup for strategic command posts on the ground, on the seas, or in the air, such a Spaceborne Nuclear Forces Command Post is at least a possibility with this large station. With access to communications satellites, there is no reason such a command post could not do the job perhaps even more effectively than alternative means.

Another Command Post use for this large station would be for controlling space forces. Eventually, satellites will be tracked and commanded from other satellites. There is no reason why the space station cannot be used as an intelligence fusion center in space, collecting information from a large number of satellites about conditions all over the world and then commanding the satellites to focus on areas which appear to the cosmonauts and their computers to be particularly worthwhile. A special type of satellite that would likely be controlled from a large station would be an orbiting anti-satellite system which is expected in the next ten years.

If the Soviets should choose to put an antiballistic missile system in space it would no doubt be quite extensive and in need of periodic maintenance. A large space station easily could be used as a maintenance and repair depot for such a system, or for that matter, for numerous other spaceborne systems. The large space station also could be used for reconnaissance as well as for a research and development laboratory for future military space applications. With all of this military capability on their 100-man space station, it is likely that the Soviets will have one or more protective systems aboard which also could have offensive capabilities.

Finally, we come to the real payoff from the Soviet military space program which will result from the expenditure of an

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estimated $350 billion or more over the next ten years – again not counting launch and operations costs. That payoff is in weapon systems. The Soviet weapons systems fall into roughly three categories: ASAT systems, Ballistic Missile Defense Systems, and Space-to-Ground Weapons.

ASAT Systems

Within ten years, the Soviets are expected to have expanded their four current ASAT capabilities (Electronic Warfare, the Co-Orbital ASAT, two ground-based laser ASAT sites, and the nuclear-tipped Galosh antiballistic missile system) to perhaps nine or more. According to "Soviet Military Power – 1984:"

> "Emerging directed energy technologies are seen by the Soviets as offering greater promise for future anti-satellite application than further development of orbital interceptors equipped with conventional warheads. The Soviets could deploy anti-satellite lasers to several ground sites in the next ten years or they could deploy laser-equipped satellites either available for launch on command or maintained in orbit, or could deploy both...The Soviets could test a prototype laser anti-satellite weapon as soon as the late 1980s. Initial operational capability could be achieved between the early- and mid-1990s."

It is likely that one of these laser weapon systems will end up on the large space station for protection of the station and for ease of testing. Laser weapon satellites could be in any orbit but the most useful would be at geosynchronous. Recall that the large booster is expected to be able to put 100,000 lbs. into that orbit although that estimated weight is somewhat less if the payload were going retrograde, or in the direction opposite to the earth's rotation. A large laser put into this type of orbit would pass within range of each of our geosynchronous satellites within about 12 hours. To see the extent of the threat that such a device would be to the free world, consider that by 1990, fully 90 percent of the West's communications traffic will flow through these satellites. Even if we ignore the damage that would be done to our defenses, just imagine the damage that could be done to our economies if we suddenly lost that communications ability. There are at present no plans of which the writer is aware to defend actively against the appearance of such a threat.

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As mentioned previously, the current space planes or larger variants also could be used as an ASAT. They would be particularly useful in orbits in which only a few very important satellites are in residence.

The Soviets are at least equal to the U.S. in particle-beam weapon technology and these also could be used effectively as ASATs, especially against the sensitive electronic components of these systems. Such a system intended only to disrupt electronic components could be tested in space in the early 1990s and one designed to physically destroy satellites could be similarly tested by the mid-1990s.

Ballistic Missile Defense Systems

The subject of Soviet Ballistic Missile Defense (BMD) systems in space is incompletely covered by the latest Defense Department documents. However, the most likely types of defenses are laser beams, particle beam weapons, and kinetic energy (high velocity impact) devices. Since there are a number of reputable scientists and engineers in this country who maintain that we could field less-than-perfect directed energy BMD systems in the near future if we wanted to, and since most acknowledge that the Soviets are at least equal to us in these technologies, it is reasonable to assume that we may be facing these types of systems in the next ten years. Various estimates put the Soviets in other technological areas from three to fifteen years behind the U.S. However, in the kinetic energy area, the U.S. was prepared to field such a BMD system in space (Proejct Defender) as far back as the late 1960s. Also, the Soviets have the world's only operational kinetic energy kill system in space and have had it for thirteen years – the co-orbital ASAT. So, the prospects for the emergence of this type of space based BMD system are probably greater than for the other two kill mechanisms. In addition their huge new booster being prepared for flight-test will effectively remove weight constraints on the design of BMD systems.

Space-to-Ground Weapons Systems

If the Soviets succeed in getting an operational three dimensional navigational satellite system as discussed earlier, they will have the key ingredient for the ability to hit targets on the earth

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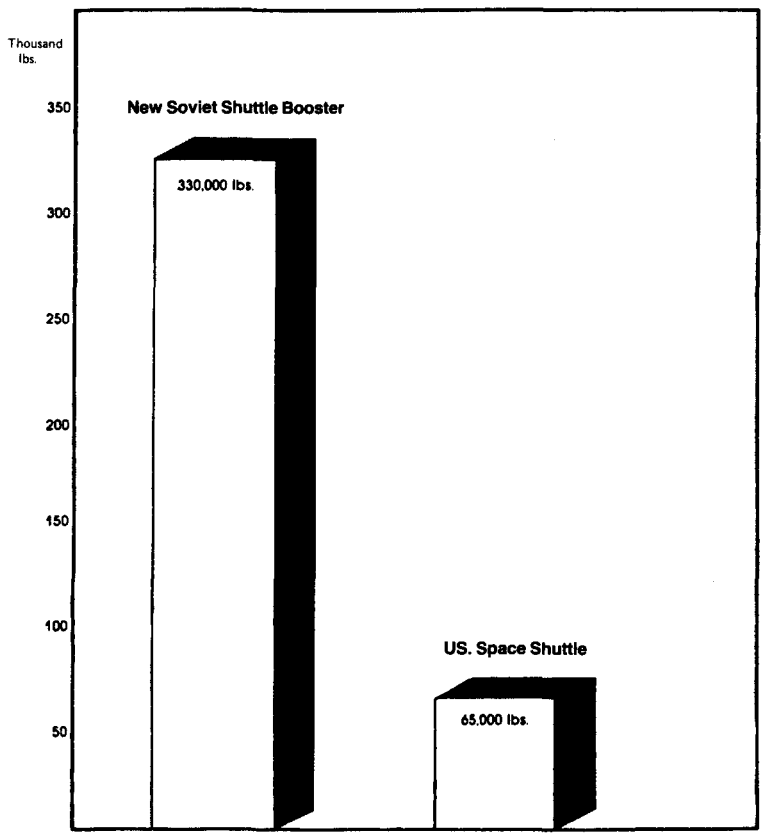
MAXIMUM PAYLOAD INTO LOW EARTH ORBIT



Source: National Center for Policy Analysis

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TABLE 1

THE SPACE RACE

(All numbers approximate)

	USSR	U.S.
Number of satellites currently in orbit	120	120
Launches per year	100	17
Payload launched per year (lbs)	660,000	66,000
Maximum payload per launch	330,000*	65,000**
Number of "killer satellites"	50	0
Number of manned space stations put into orbit	7	1

* Capacity of the new Soviet booster under development

** Capacity of the U.S. Space Shuttle

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with precision from space by using hypervelocity (tens of thousands of feet per second) non-nuclear impact devices. The implications of this for modern warfare would fill an article by itself. Imagine ships being sunk in port, munitions storage dumps destroyed, hardened silos vaporized, and numerous other high value targets taken out worldwide, within hours, without lengthy mobilization of forces or the occurrence of damage to surrounding civilian population areas.

With all the interest in Ballistic Missile Defense in this country since President Reagan's "Star Wars" speech in the spring of 1983, it is surprising that in some ways an easier but equally effective use of laser technology in the strategic and tactical sphere has been all but ignored. It is an area in which the Soviets probably are at least equal to us. Many technologists agree that it is easier to destroy aircraft from space using lasers than it is to destroy ballistic missiles. A potential threat that we could be facing from space in the next ten years would be lasers directed against bombers, cruise missiles, Airborne Warning and Control System aircraft, tankers, and tactical aircraft both ground and naval based.

Conclusion

Unless the U.S. does something it is not now planning to do, and does it fast, sometime in the next decade the Soviets will have achieved their objective of mastery of space all the way out to geosynchronous orbit. By then they may have nine types of ASAT capabilities, a 100-man Command Post in space, space-to-ground and space-to-air weapons, a less than perfect but effective ballistic missile defense system in space, and all the support satellites a modern force could wish for, with the ability to defend them.

Unless the U.S. develops a large number of low-altitude ASATs and ASATs capable of destroying different types of Soviet ASATs in orbits up to 20,000 miles above the earth, we will not be able to be assured of the survivability of our own space assets, nor will we be able to negate the considerable military assets the Soviets will then have in space. In addition, should we fail to rapidly develop a ballistic missile defense system in space, the Soviets could well prevent us from ever doing so by the construction of their own first.

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FREEDOM, SAFETY AND SURVIVAL IN THE NUCLEAR AGE: A DECLARATION OF INDEPENDENCE FOR STRATEGIC POLICY AND NATIONAL WILL

By Robert W. Bussard

National Will and the Beginning of Our Nation

Over 200 years ago the brilliant and dedicated men who founded our country lit the light of freedom on the North American continent. The struggle took twelve years from its formal beginnings in 1976 until it's conclusion with the adoption of the U.S. Constitution in 1788. That twelve years was a time of trial for our country, with contending factions arguing for differing socio-economic models of "freedom" for the citizens of their several independent States and Commonwealths – which had not long before been the 13 Colonies of England and King George III. The general consensus reached by 1788 was sufficient to allow the adoption of our Constitution, which endures to the present day.

These Founders of our country, Franklin, Jefferson, Adams, Washington, and all the others, were drawn together by a commonality of despair. The individual liberties of the free Colnists had been legislated away, and oppressive policies constraining trade and taxation had been imposed one by one, until their burden was too great to bear. As late as 1774 the governments of several Colonies petitioned the King to restore their rights as free Englishmen – to no avail. Driven to despair, but full of desire and hope for the new nation they could sense emerging on this continent, our Founders placed their worldly goods, their very lives, and – as they said – their "sacred honor" on the block when they took that first, awful, terrifying step of declaring themselves and their colonies to be free and independent of overseas domination and control.

The Current Predicament

We, today, have suffered for 20 years or more in a mode of growing public despair and malaise, which has led to a situation

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as impossible for us now as was that confronting the delegates in Independence Hall in the Summer of 1776. We have been trapped by an ever more precarious suicidal nuclear strike doctrine vis-a-vis our nuclear adversaries, the Soviet Union, largely as a result of the failure of our national will to exercise our strengths when needed to preserve our principles and positions in the international jungle. As pointed out by Miranda,(1) Soviet political warfare has been waged successfully against us to progressively erode our ability to act in our own best interests. More than two decades of accommodation to international pressures and "world opinion" have been given us by politicians and the public media, yearning to avoid any serious confrontation with our enemies. For decades we have surrendered, a mile at a time, the hard-won ground of liberty and its defense, to a hostile world in which governments based on collectivism, not individual freedom, have sworn to "bury" us and all that we are and for which we stand.

We have now reached a state where the strength of strategic offensive weapons systems in the hands of the Soviet Union far exceeds our own, where our navies are challenged and matched upon the seas, and our armies are far over-matched on the ground. We have let it all gradually slip away, almost unnoticed, by policies of "detente," willingness to accept "parity/equality" in the nuclear balance-of-terror, acceptance of SALT talks and treaties which have led to the growing strength of our foes and the gradual weakening of ourselves.

There is nothing wrong with the people of America – we are still tough and independent souls who, in the large, cherish our freedoms and despise unwarranted constraints; who want safe homes and firesides, and who are willing to fight for them if we know they are endangered and if we are given the chance to do so. Yet the dragon of despair has crept up on us in the dark night of murky international politics – despair at our inability to act to break the pact of suicide by Mutual Assured Destruction (MAD), which we have made unilaterally with the Soviet Union. Frozen in congealing amber for the past 20 years, we have reached the same state as did our Founders when they first thought to act, in 1774-75, to try a new direction for the preservation of free Americans. Now *we must try a new direction* to escape the failed MAD doctrine of the past, if we are to have hope of survival. We can no longer afford to act out of fear, through failure of our national will.

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The Failure of Will in International Conflict

Our international policy failures in serious conflicts since World War II have all resulted from such "Failures of National Will."(2) Indeed, our policies of conflict strategy over this period have all exhibited the *same* characteristic failure of will, and thus qualify as a classic modern example of "Folly in Government" as defined by Tuchman.(3) Such "Folly" is "the pursuit of policy contrary to the self-interest of the constituency or state involved," carried out by a succession of rulers, even though "feasible alternative (positive policies) were available and perceived at the time."

Our first such major failure in modern times was in Korea, where we allowed the Chinese to attack us across our blood-bought Korean borders while imposing on ourselves, by our will, the limit of not attacking them across their borders. By the time our ground forces reached the Yalu river bordering North Korea and China – and the infamous Chinese attack on us across that river began – we had baptized the Korean peninsula with the bodies and blood of 28,000 dead Americans – and our G.I.'s were *jus sanguine* citizens of Korea as surely as any child born in Seoul.

In this state of affairs – defending our thus-adopted land – our government imposed a rule on our own troops which could only ensure our eventual defeat. A rule which said that we were not allowed to attack those – in their homeland – who were attacking us – in "our" homeland! This failure of will was subjectively felt by both sides as a virtual surrender by us, with a guarantee of forfeiting the victory which was, at that moment of the war, ours. From that moment we adopted a policy of defense-with-limited-arms which was foredoomed to failure.(4)

This de facto surrender filled our nation with an unspoken shame, and generated a psychological disgust with and distrust of our government, which reached its epic peaks in the vast citizen-public backlash to the Viet Nam war, and which haunts us still today in the mating dance of citizen and government over issues of defense of Central America, Lebanon, etc.

This final surrender act in the Korean War was presaged by precursor policies imposed on the fighting troops as they won their way North from the Pusan perimeter to the Yalu bordering Communist China. These policies said, "Thou shalt not use thy full force to win in the extremity of any battle." In short,

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our forces were denied the use of the power of our nuclear weapons – even to save our own lives. One tactical nuclear weapon used at Heartbreak Hill would have ended the battle as it began, and saved about 5,000 U.S. and 10,000 Korean lives. These precursor restrictions arose from failure of the will, when the government was confronted with the notion propagated widely in the media that – somehow – defense of ourselves with our full strength would cause the war to escalate into a global nuclear conflict; a point of view which was then and remains now completely groundless.

The President, as Commander-in-Chief, adopted this policy of failure and was opposed by the military commander, General MacArthur, who resigned in protest to this surrender of American principles. The ensuing outpouring of public emotion attendant on these events allowed the media as much needed catharsis of patriotic fervor before turning to its more serious pursuits of denigration, intervention, and complaint about our country, its history (we took it from the Indians!), its technology (bad nuclear, dirty coal!), its strengths (we are the bad gunslingers in town, with black hats; the Soviets and Communist Chinese are the two virginal schoolteachers!), and its hopes for national (not first international!) good.

The Soviet apparatus which helped to orchestrate the self-flagellating public opinion of the U.S., so well spread as the new "gospel-of-repentance-for-our-strength" by the media of our land, was ecstatic with our Korean surrender politics and saw this mechanism – the stimulation of public shame and contrition for our very virtues of toughness and will to survive – as winning in its constant war for dominion over and direction of our public political moral guidance and policies. And win, indeed, they have. Pouring out from Institutes in Leningrad and Moscow, covertly entering the U.S. as peace movements of various types, kinds and descriptions, as "minority" movements, "environmental" movements, "anti-nuclear" anti-technology, and finally anti-U.S. movements – they have been (in the past) successful in creating a climate of shame and guilt among our more susceptible, gullible, and poorly-informed people. Indeed, as so ably discussed by Miranda(5) Soviet political warfare, which has produced this result of national despair, has been a triumphant achievement of our adversaries.

The revival of will exhibited by President Kennedy's hard and unmoving military stand on the presence of Soviet missiles in

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Cuba offered a brief and uplifting recovery of our national spirit, after the malaise of our Korean surrender. But this was short-lived, propagandized by the Soviet line echoed in the "liberal" media on the "awfulness of nuclear war." We were painted – by our own public pundits – as war-crazed aggressors stalking the world with blood in our eyes and nuclear lightning in our hands. Came Viet Nam and our public nerve gave way again to the surrender principle inherent in the policies adopted by the government as the war began. No attack was to be allowed on the sources of supply of our enemies, and no use was to be allowed of our full military strength – i.e. no nuclear weapons. We could not ever win a war under such self-imposed constraints, and we did not, a situation which will appear nearly incredible to future historians. This purposeful failure of will simply extended our descent into the pit from which we now must climb for our survival.

We had not yet learned, as a public body, that there can be no sure defense of our freedoms, or of any of our adopted friends or allies, without the commitment of all of our strengths and resources to such defense. It is axiomatic that publicly expressed limitations of our commitments to only a portion of our strength is tantamount to public admission of lack of will to defend, and invites the attack of our enemies. All history proves this to be the case. We are slow learners and come from a different ethic than most nations of the past. We are basically a Christian nation attempting to operate on Christian principle, yet trying to survive in the largely pagan world, where our enemies are those of collective government called communism (the Soul of the Hive). It is because of this underlying ethic that we are the only nation in history which possessed the power – with complete certainty for almost ten years (1945-55) – to capture and control the entire world, and never exercised it.

Reliance on MAD and strategic offense is the way in which we have finally become victims ourselves of our policies of failure-of-will. For, under the MAD doctrine, we will never utilize our strategic offensive power to strike and kill our enemies until we, ourselves, have been destroyed. This is scarcely the way to defend our people, to allow them first to die. Only by strategic defense does the failure-of-will policy/ethic cease to function and affect us, and thus leave us with our lives in safety, when an effective strategic nuclear "first-strike" can no longer be made on our homeland. In our modern world of

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propaganda, media disenchantment, and communist disinformation, the public defense of free people, the rights of the majority as well as of individuals, and of our capitalistic value-added society requires an iron will, unswerving conviction, and a determination to outlast all the critics carping from every side. One must almost have the strength and fortitude of an Ignatius Loyola to withstand the onslaught of the past two generations of naysayers. And today the naysayers are saying that the Soviet threat is not real or is overstated, that effective strategic defense is impossible, and that our only hope is more MADness.

The Reality and Nature of the Threat

The real enemy is that political force loose in the world which places governments above people, conformity to the State above individual liberty, rigidity of thought above freedom of expression. This force finds its greatest and most threatening embodiment in those nations espousing "communism," and whose governments operate dictatorially on models of State planning in which individuals are "workers," not free citizens. An organized dictatorship is an efficient form of government – in its ability to exploit and build on human and other national resources – but it is not a free one. Independence of spirit and of the mind is not a valued national asset in such societies. For this reason alone a free society will always prevail in the long run of things – provided it can stay alive to do so.

Staying alive in the jungle of the world does not happen by agreeing with our enemies. Their interests are theirs, not ours. Staying alive requires that we hold fast to all of our principles and stand firmly on the grounds of the rights of free men to remain free, as did the farmers at Concord Bridge so long ago. The first five American war dead are buried under a small monument on Lexington Green. They died never knowing whether their cause would triumph, but believing it essential not to agree to accommodate to the King's soldiers. We now face a world of media, politicians, and minority agitation groups which wants us to accommodate still more to cries of "peace," "detente," "co-existence" and all the other clap-trap of left-wing communist favoritism which seeks "peace in our time – at almost any price." We must not respond by agreeing with these products of political warfare. We are capable of deciding

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what is best for us, for our nation and our people, and we must now look to our own safety and our own new weapons needed to guarantee that safety against the failed MAD doctrine and the strategic threat of our enemies.

The size of the threat is quite frightening when it is viewed fully and clearly, beyond the fogs of political "peace" rhetoric. A realistic assessment of real facts shows that the balance of strategic power between the U.S. and the Soviet Union has grown monotonically larger in favor of the Soviets, ever since WWII. The Soviet Union has 5 more ICBM systems than have we, with over 3 times our nuclear weapons delivery capacity. Their missiles have accuracy at least as good as our own, and the hardness and survivability of their missile silos is at least as good as ours. The yield range of their nuclear weapons extends beyond ours, and their nuclear arsenal is far greater than need to destroy America. They have massive civil defense preparedness; we have none. They have a decade-long lead on us in development of technologies for energy weapons important to strategic defense, and a deployed ICBM defense system within the limits of the SALT I treaty.

Their first-strike capability is awesome; all realistic analyses suggest that such a strike would take out very much more than half of our retaliatory capacity (perhaps even 90% or more). In addition, the Soviet fleet outranks our own in those new kinds of ships which will matter most in any future conflict; they have 3 times our nuclear submarine production capacity, and have developed newer and faster nuclear submarines. Soviet strategic aircraft are at least as fast and maneuverable as ours (Backfire vs. B-52), their rocket launch rate to space is more than 3 times ours, and they continue to orbit a succession of nuclear reactor space satellites for intelligence data-gathering (we orbited one space reactor, over 20 years ago). Most importantly, they have shown a never-wavering commitment to acquiring the high ground of Space.

Unlike our space program, which took a "one-shot" goal of lunar landing and then died as the Viet Nam war engulfed us (to be revitalized a decade later by the beautiful Shuttle), the Soviets have kept up an unrelenting launch rate into orbit, with ever increasing launches and payloads. They have occupied a manned space station now for over 4 years, and it has been made larger over that time by further assembly in space. Their array of communications, navigation, and spy satellites matches

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our own. Their work on high power lasers, special nuclear weapons, particle beams, and high power microwave tubes started years before our own, and had been pursued with great vigor and at great cost – aimed at the eventual development of defensive weapons systems to render our counter-forces ineffective; in short to destroy the MAD doctrine, unilaterally in their favor.

As this happens – and it is happening now – our MAD doctrine will fail in a cataclysmic way, and we will be left without any provision for "the common defence" of our nation and our people, a state which can be prevented only by immediate mobilization of American industry and ingenuity to build true strategic defense systems. Under current MAD imbalance conditions, a Soviet first strike would ensure that our cities and citizens be hostages against a U.S. second strike response, by virtue of the limitation of Soviet first strike to U.S. military targets. In such a case, no one in Washington is going to order the killing of tens of millions of Soviets in their cities when the damage inflicted on us is limited largely to Minuteman bases and U.S. submarines at sea, and when such a U.S. strike would elicit an immediate 100 megadeath response on our own cities. This is MADness, indeed!

The Soviets are not nine feet tall – they are no better than we at such things and are, in fact, far worse in some respects because of the immense burden of their governmental bureaucracy. But they are dedicated, committed, and continue to put huge resources of people and money into their national military machine. Khrushchev's boast so long ago that, "We will bury you," was no idle threat, no simple political rhetoric. He was speaking from his knowledge of what they really were and are doing to overwhelm our ability to defend ourselves. The only answer to the *real* problem is to ensure that we remain strong enough to keep our enemy at bay, by reducing his ability to strike at us, while retaining our own offensive force. Peace will come only when the Soviets understand that it is the only alternative allowed by the strength of the West

The MAD Doctrine: Politics, Technology and the Roots of Failure

That our enemies have been able to reach a commanding and growing advantage over us is no accident. It is a product of

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Soviet drive and initiative to build ever-stronger aggressive offensive military forces, coupled with major efforts by Soviet disinformation and propaganda mills to lead us into a false sense of security under which we would not do, and so far have not done, those things necessary for our long-term survival. In this latter effort they have had the helping hands of our side of a succession of American governments who failed to tell our people of each new escalation of the threat, who often-times did not wish, even in the face of measured facts, to admit the existence of such threats. Supporting and pushing our successive governments in this propagation of Tuchman's(6) "Folly" has been the press and TV. media, with the pacifist element of the science community, which have propagandized us for decades to think that the Soviet's intentions must be like our own – peaceful and seeking only to live in "peaceful co-existence."

Those who hold such views discount massive Soviet military developments of country-killing weapons systems and argue that these developments must be misunderstood, or be for other purposes than to attack the West (e.g. defense against the Chinese), or possibly be exaggerated or even non-existent. Such denial of the reality of the technological and developmental conflict of the past 35 years between ourselves and our adversaries serves no purpose to ourselves. The nature and scope of this technological war has been brilliantly described by Possony and Pournelle(7) in a recent summary section drawn from their earlier book on the strategy of technology.(8) In this they point out that, "Because the goals of the US and the USSR are asymmetric, the strategies each employ in the Technological War will be different. The US is dedicated to a strategy of stability, of being a stabilizing power;...(while) the USSR is expansionist; aggressive; a disturber power which officially states that the only true peace is that of world Communism," and that, "the Technological War is most real, and we must understand its nature, for it is decisive. Our survival depends on our not losing this battle." And the battle which matters is, of course, that of the development of country-killing strategic nuclear weapons delivery systems – a battle the Soviets have been winning, and continue to win to the present day.

In the complex interaction of facts, beliefs, analysis, and propaganda embracing the strategic technological conflict we have helped the cause of our enemies immensely by a continuing almost-blind adherence to a national doctrine for strategic

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survival that was invented and adopted over 25 years ago. This is the doctrine of Mutual Assured Destruction (MAD) and "mad" indeed it is, today. This doctrine is based on the twin notions that:

(I) No defense is possible against nuclear weapons carried by ballistic missiles.

(II) No nation will strike another if the victim can strike back strongly enough to ensure annihilation of the aggressor.

The MAD doctrine was technically and philosophically correct at the time (mid-1950s) of its adoption as the basis for our national defense development policies. Then, neither we nor anyone else knew how to defend against nuclear-bomb-carrying ICBM systems. However, in the Soviet Union at about that time another very different doctrine was emerging. This formed it roots in the rightly-placed Soviet faith in the power of technical development to lead to new capabilities, and thus to new allowable ground rules – and, in particular, to the negation of the first presumption (I, above) of the MAD doctrine.

In 1956 the great Russian physicist, Peter Kapitza – then a principal scientific advisor to Khrushchev – wrote his convictions that defense against nuclear weapons was, in principle, feasible and inevitable, but that it would require the development of "great energetics."(9) He foresaw the need for the development of massive defensive weapons systems of very large power and very large scale, but saw no basic technical obstacles to their development. Significantly, his paper was written in response to an article published just previously by Bertrand Russell,(10) that peculiarly-misguided pacifist, who asserted that the way to prevent "Atomic War" is to "Avoid the Use of Nuclear Weapons" (precursor to the current public fantasy of the so-called "nuclear freeze" movement). So we have the viewpoints of East vs. West in 1957; Kapitza in Russia outlining technology to avoid nuclear war by the development of strategic defensive weapons; Russell in England urging negotiation to prohibit or avoid such developments.

Inside the Soviet Union the policy followed was Kapitza's and by 1960 a new Soviet doctrine emerged and became the basis of all Soviet policy to the present day. This doctrine(11) said that, "there *is* going to be a nuclear war, and we [the Soviet Union] are going to develop the tools to win it." *Outside* the Soviet Union their policy was to agree with Russell's philo-

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sophy, and they embarked with us on a long series of treaty negotiations designed to weaken us (following Lenin's dictum that all political means are to be used to win the conflict with capitalism), to limit nuclear weapons testing in the atmosphere, to limit testing underground (which they have broken several times), to ban weapons from space, to limit ABM systems and developments, to stop, limit, restrict – at any way possible – the development in the West of the very technologies and weapons systems needed for Kapitza's defense against nuclear attack, which they themselves were pursuing with great national efforts.

So our politicians and our media opinion-makers bought the idea of negotiation and the corollary "lack" of Soviet threat, and have been selling it to us (and themselves) ever since. And this is why we find ourselves embroiled in "arms control" negotiations and debates – a result of 20 years of Soviet attack on our will (and support of our folly) by constant reinforcement of the Russell doctrine in the West, supported by our own tendencies towards peace and our own initial belief in the MAD doctrine carried forward to the present day. We hear echoes of the state of affairs under King George III and the 20 years of gradual weakening and oppression of free citizens of the Colonies, which so troubled our Founding Fathers.

But, like those times, the truth of the world situation has long since changed over that 20 year span. The MAD doctrine, once valid, has become less and less so with the passage of time and the continuing advance of science and space technology, until today it is incontrovertibly false, and is "mad" indeed. To pretend to believe in its original precepts in the face of Soviet and our own technical advances since Kapitza is as mad as the MAD doctrine itself.

Part of our willingness to cling to this doctrine is our general American belief that, "the best defense is a good offense." But, like all other cliches, this one is true sometimes and false others. Just ask the Washington Redskins if their "DE-FENSE" was crucial in winning ball games in recent years. Or, for those of us old enough to remember, it was the technology-based defense of radar target acquisition which enabled the British to defeat Hitler's Luftwaffe in the Battle for Britain. There a handful of RAF planes and pilots slaughtered the best of the German air force on their massive nightly raids over England and, even though perfect interception was never achieved, made

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the price so high that Hitler abandoned plans for a cross-Channel invasion and instead turned east into the impassable morass of ground war in the Soviet Union.

Offensive and defense are both necessary, whether in football, business, or stategic conflict. Our faults over the past 20 years of mad MAD doctrine have been:

(1) To fail to recognize the erosion of our ability to defend America *by offense alone,*

(2) To ignore the Soviet buildup of strategic defenses against our offense, and

(3) To be lulled into a belief that development of realistic U.S. defenses against the ever-more-powerful Soviet offense would be destabilizing of world peace.

These conclusions are exactly those desired for us by the Soviet political apparatus orchestrating the political war.(12)

We Can Have a Real Defense

The only way known to defend against nuclear missile attack is to destroy the missiles or their nuclear weapon payloads before they reach their targets. Can this be done? As Kapitza said,(13) in 1956, "...it is impossible to deny the possibility of finding such a method [to stop nuclear missiles], although it is a very difficult scientific and engineering problem...." Now, 28 years later, the answer which comes from all modern technology is a resounding *yes*; whether for intercept in missile boost phase, post-boost and mid-course, or at target terminal end of the ICBM-weapon trajectory.

To destroy missiles or their warhead packages we must blow them up or otherwise dismember or disable them. This can now be done by interception with ultra-fast rocket interceptors carrying nuclear or non-nuclear warheads. While nuclear explosives can be used in space with minimal collateral effects on the ground, it is not necessary to employ such devices for effective anti-ballistic-missile (ABM) defense. Modern space, guidance, and related technologies make effective interception and kill possible by use of non-nuclear warheads which "kill" their target by collision, utilizing the huge kinetic energy associated with their very large collision speeds. In short, we can now "shoot" ICBMs and RV/warheads with high speed space-launched "bullets," which *require no new technology for their development.* We know how to do this today. All that is needed

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is our national will to pay the cost of such systems for our own survival. Is our survival at stake? We need only appeal once more to Kapitza,(12) writing from a Soviet point of view, when he said that countries which, "...are the first to find an effective means of defence from the nuclear arm,...can 'forget about' any of their obligations. Either they may unleash an atomic war, or in any event use their advantage to impose their will on others...."

Beyond these early and buildable non-nuclear kinetic-energy defensive stystems lie the exotic defenses of the "star wars" era, defensive weapons which shoot beams of light, or atomic particles at light speeds – the so-called "directed energy weapons" – and still others which use nuclear bombs themselves to drive the directed energy of X-rays. Development of the technology of these is underway in the U.S. (5-10 years behind the Soviets), but in need of vastly more effort for success in time to yield effective strategic defensive systems to replace the non-nuclear systems we can build now. Such more advanced systems might be possible around the turn of the century. The important fact is that we now see as possible a full panoply of means to defend our territory and people, and that of our allies, with nation-saving defenses against any attack, capable of improvement over the years as new and more advanced technologies are proven practical. If we are to succeed in saving America *we can and must start now* with what we *now* know how to do; we must not wait for still-future science to bear fruit. To fail to do so would be to abandon our original commitment to the cause of liberty and free men, and thus to fail not only ourselves but to allow the death of the last bright hopes of our troubled world.

Towards a New Beginning

The size and scale of defensive systems using non-nuclear warheads to shoot at enemy missiles is much greater than that of most space-based systems which we have so far deployed in the ongoing technology war.(13) This means that we must build and deploy a great many of these hypervelocity "rocket/gun" systems to ensure the safety of our own defended sites and cities. But that is exactly what we Americans do best – develop what we know how to develop, and manufacture it well in quantity. Early studies show that between 200 and 600

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space platforms must be deployed to provide an initial defense system which is adequate (but never perfect) to deter Soviet aggressive impulses, and thus reduce the probability of nuclear war. No defense is or ever will be perfect, allowing no attackers to get through; what is needed to begin with is one that makes the enemy lose too much to make an attack worthwhile (witness the RAF in WWII). The reason that the simple non-nuclear kinetic-energy kill defense *will* work is simply that it is considerably cheaper to build such defenses than for the enemy to develop and build whole new ICBM/warhead systems to counter them. And by the time he could have done so, assuming he is willing to meet the expense, the second and third generation defensive systems using more exotic technologies will be available, provided we have had the will to continue their development. These first systems are well-understood; no new science or technology is involved (only new systems), and American industry could be put to work tomorrow to start the building of these new and better guns over our fireplaces.

The cost of such a strategic defensive "umbrella" is enormous, but it is far, far less than the value of any one of our cities, or of our people who live in these places and in the surrounding countryside. In fact, the cost of a fully deployed first-generation system is considerably *less* than we have spent over the past 30 years on our strategic offensive "Triad" (SAC, ICBM, and SLBM forces) required to support the MAD doctrine for retaliatory delivery of nuclear bombs on an enemy who had already attacked us and laid our land waste. It is conservatively estimated that the real cost (in today's dollars) of that past expense is over $300 billion dollars. The most straight-forward non-nuclear kinetic-energy-kill systems fully deployed would cost less than one-fourth of this. *Full deployment* would take about 12 years; about the time that was required to make our Nation from our Independence start in 1776. Certainly safe defense is worth at least a fourth as much as post-destruction offense.

But, that is not all. Starting down this road can and will give America a new breath and smell of free air on a new and grander frontier than ever confronted us in the Great Western Wilderness on this continent. This new frontier is the High Frontier of space. We have sampled this in the Apollo program when our Flag went on the moon, and we continue now with our Shuttles as they climb orbit-bound from the Cape. But

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realistic expansion into this new frontier will occur only when private industry and government *together* embark on massive developments of space industry, solar power, and U.S. colony/cities in space and on the moon and other planets. This can not take place until we have secured the high ground of space for our defense against the threat of nuclear missile attack. Development of the strategic defense systems we now need will ensure this and will give us our "cavalry forts" in the Wilderness of the High Frontier. U.S. superiority in space technology, engineering development and manufacturing guarantees our success, in both the near- and long-term aspects of space systems deployment and use.

Once the Soviet aggressive strategic strike threat is negated, they will have lost forever, for they can never catch the West with high technology and productivity. Given a peaceful world, held stable by effective strategic defense systems, our ability to develop further through expansion into space will channel the East/West conflict into the world economic arena; a race which can be won only by the power of productive capitalism. Thus, if we act now to defend ourselves, we will have produced a situation in which Soviet "communism" in particular, and state collectivism in general, will dwindle away as non-utile forms of government for the competition inherent in the life of nations.

If we fail now to build our essential strategic defense – if we persist in remaining MAD – freedom will die a shameful death under the ever-growing might of aggressive foreign tyrannies, and a long night of darkness will settle on the land. The doctrine of Mutual Assured Destruction has failed, and all of its supporting policies. We need a new doctrine of Assured Survival, with all supporting policies to develop effective strategic defense. Let us now make a new Declaration of Independence for our times and conditions, with pride in the tasks and responsibilities required to lead our country and the world, to a safe and brighter future. It is time for our leaders to honor, once again, the Constitutional imperative to "...provide for the common defence..." and thus to "...secure the Blessings of Liberty to ourselves and our Posterity...."

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FOOTNOTES

(1) Miranda, J., "Political Warfare: The Decisive Strategy," *Journal of Social, Political, and Economic Studies,* Vol. 8, no. 4, Winter 1983, pp. 427-448.

(2) "Will" as a force in government policy has never been better demonstrated than by Hitler in his propagandization of the Nuremburg Party Congress of Nazi Youth, in 1934, documented in Leni Reifenstahl's famous propaganda film, "Triumfe des Willens," which captured the German public for the Nazi cause.

(3) Tuchman, B.W., "The March of Folly From Troy to Vietnam," The Twentieth Cosmos Club Award lecture, Cosmos Club, Washington, D.C., October 4, 1983 (see also Tuchman's book, Folly in Government – From Troy to Vietnam, publ. Spring 1984).

(4) By this action we failed to note and apply the lesson bitterly learned by the South in our own Civil War, that defense alone of one's homeland (the Confederacy) can never win, if that "defense" allows the enemy (the Union) to pour troops and weapons across one's own borders with impunity.

(5) Miranda, J., "Political Warfare: The Decisive Strategy," *Journal of Social, Political, and Economic Studies,* Vol. 8, No. 4, Winter 1983, pp. 427-448.

(6) Tuchman, B.W., "The March of Folly From Troy To Vietnam," The Twentieth Cosmos Club Award lecture, Cosmos Club, Washington, D.C., October 4, 1983 (see also Tuchman's book, Folly in Government – From Troy To Vietnam, publ. Spring 1984).

(7) Possony, S.T. and Pournelle, J.E., "The Technological War," in Men of War, a Tor book, publ. by T. Doherty Assoc., Inc., New York, 1984, pp. 57-81.

(8) Possony, S.T. and Pournelle, J.E., The Strategy of Technology, Univ. Press of Cambridge, Mass., 1970.

(9) Kapitza, P.L., "21. How Is Atomic War To Be Prevented; (2) The Task of All Progressive Mankind," in Collected Papers of P.L. Kapitza, Vol. III, ed. by D ter Haar, Pergamon Press, Oxfore/New York/et al, pp. 154-157; originally written in 1956.

(10) Russell, B., "...; (1) Avoid the Use of Nuclear Weapons!," in Kapitza (7), p. 153; originally written as an article in the British journal, *New Times,* 1956.

(11) Miranda, J., "Political Warfare: The decisive Strategy," *Journal of Social, Political, and Economic Studies,* Vol. 8, No. 4, Winter 1983, pp. 427-448. (see also Kintner, E. and Scott L., Soviet Strategy In the Nuclear Age, McMillan Co., New York, 1952).

(12) Kapitza, P.L., "21. How Is Atomic War To Be Prevented; (2) The Task of All Progressive Mankind," in Collected Paper of P.L. Kapitza, Vol. III, ed. by D ter Haar, Pergamon Press, Oxford/New York/et al, pp. 154-157; originally written in 1956.

(13) Ibid.

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IT'S TIME FOR HIGH FRONTIER

By Daniel O. Graham

High Frontier is a non-profit, public education organization which has over the past three years researched and publicized ways and means for the United States to apply our superior space technology to the solution of our national security and economic problems.

While space represents literally unlimited opportunities for economic progress, the most pressing recommendation of High Frontier today is that we seize our historic opportunity to discard the dangerous and unethical precepts of the Mutual Assured Destruction or MAD doctrine through space-borne defensive systems. MAD is an all-offense, vengeance-oriented doctrine, which would doom us all to live in a precarious nuclear balance of terror for generations to come. The MAD doctrine insists that we leave our people undefended from the awesome threat of nuclear destruction in order to assure the Soviets that we will never strike first. The MAD doctrine permits us only two options for security in the nuclear age – constant and wildly expensive efforts to refine our offensive nuclear forces (e.g. MX-Racetrack) or the scarcely believable hope that the Soviet Union will become a reliable co-guarantor of our security through agreements. MAD leaves us perpetually on the brink of disaster, either as a result of a deliberate first strike, an accident, or miscalculation, or as the result of nuclear missile proliferation. This need not be so.

We can escape this awful dilemma by changing the nature of our deterrent. Nuclear war can be avoided by fielding non-nuclear ballistic missile defense systems which destroy offensive weapons rather than cities and people. We can deter a first strike by denying any chance of a knock-out blow. We can prevent accidental nuclear war by acquiring a capability to destroy the accidentally-fired or third-country-fired nuclear missile. Such capabilities are well within our reach.

* This message has been more full developed in a statement of Lt. Gen. Daniel O. Graham, to the House Committee on Appropriations, May 9, 1984.

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If we use available technology rather than waiting for the development of more exotic systems, BMD capabilities can be acquired at reasonable costs within five to six years of a decision to deploy. We believe that a trade-off of currently contemplated, long-term offensive weapons programs designed to accommodate MAD, combined with reasonable inputs from our Allies who would also be protected by a global defense system, could actually result in overall defense savings.

High Frontier's preferred technical solution to the problem of strategic defenses is kinetic-energy kill of the missiles in a three-layered system. This involves striking the target with a cloud of pellets rather than with some sort of directed energy beam. The feasibility of such a defense against long-range ballistic missiles was accepted by a presidentially commissioned study 20 years ago. It is the technology successfully demonstrated over the past 10 years by the Soviets in their anti-satellite program. In fact, High Frontier's proposal for the two space borne layers is essentially a reversal of the process successfully used by the Soviets. Their ASAT is a kinetic energy kill vehicle which is lifted into space by an ICBM which leaves the missile to strike a satellite. High Frontier sends the kinetic energy kill vehicle from the satellite to kill the missile. The first layer of such a defense can be had quickly at a reasonable and predictable price since it involves essentially off-the-shelf hardware. This system because of current sensor limitations will be able to intercept only in the first nine minutes of a missile's trajectory, and not in the atmospheric part of it. The second level of space-borne defense is designed to intercept warheads as they coast through space. This requires improvement in sensors and could use either the same sort of kinetic energy technology or lasers if technical problems are solved expeditiously. Availability of this layer is less certain but given enough impetus could be deployed in 10 to 12 years.

The third layer of defense is ground-based and uses the same basic principle of non-nuclear kinetic energy kill to protect individual silos and other hardened targets by putting a cloud of projectiles in the path of an incoming warhead. This system is immediately deployable. It is designed as a short-term, economical answer to the vulnerability of our current offensive deterrent during the transition from the Mutual Assured Destruction doctrine to Assured Survival. Such a defense can be bought for about 10 million dollars per defended silo using the GAU-8 gun

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and simple radar systems already in production, and would be over 90 percent effective against an accurate incoming warhead. Once the space-borne systems were deployed, the ground-based system would have the much simplified task of intercepting "leakers." The space-borne systems should be capable of successively filtering the missile attack by 80 percent for a total of 96 percent effectiveness.

You will note that High Frontier does not demand perfection of the strategic defensive systems. Neither should anyone else. We certainly don't demand perfection of *offensive* systems.

Critics of High Frontier and the Strategic Defense Initiative almost invariably demand a perfect defense or none at all. Their attacks start with phrases such as: "Acquiring a 'leakproof,' 'total,' 'airtight,' or 'perfect' defense ____." After having set up this strawman of perfection, they proceed at length to prove it is either impossible or would cost colossal sums of money. Furthermore, they claim, a "perfect" defense would deny the Soviets a *retaliatory* capability and thus encourage drastic action, perhaps even a first strike.

Once a perfect defense is postulated, it does not take reams of facts and figures to shoot down the Strategic Defense Initiative. There never has been a perfect defense against anything and there won't be one against nuclear weapons. If we can get a 90 percent effective defense, should deterrence ever fail, we would surely be in a better position to prevent 90 percent of the destruction we would now suffer. More important is the deterrent effect on any aggressor contemplating a first strike. He would have to be a madman indeed to contemeplate a *10 percent effective nuclear strike against the U.S. and its Allies.* Further, the Soviet Union as well as ourselves can step back from the hair-trigger stance imposed by MAD.

Those who believe the Soviets would be entitled to consider that moves to protect our people from nuclear attack mean our preparation to strike them first should perhaps be insisting that we now use *our* strike forces. While the Soviets have poured enormous sums into offensive weapons, for every ruble put into their offense, one is invested into the defense of *their* population.

Our worry should not be that the Soviets are so paranoid that they would attack us to preserve their first strike option, but that they have been diligently seeking military control of near-Earth space for many years now. Should the Soviets achieve

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their goal, they will treat space the way they treat their airspace. All entry into space will be considered hostile unless previously cleared by Moscow.

You are faced with an historic opportunity to help restore common sense and moral rectitude to our country's efforts to remain secure in the nuclear era. You can add your weight to the opinions of four out of five Americans that it is time to defend our country. By giving your full support the Strategic Defense Initiative you can ensure that the quickest and cheapest of the technical options available to us today are pursued. As soon as our superb technology will permit, the brooding menace of nuclear destruction will be removed from over the heads of Americans and people everywhere.

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EUROPE'S STAKE IN BALLISTIC MISSILE DEFENSE

By Stewart Menaul

On 23 March 1983, President Reagan proposed a wholly new concept for a defensive strategy aimed at replacing the current strategy of mutual assured destruction with one dedicated to assured survival. The proposal involved the creation of a strategic defence system against nuclear ballistic missiles, involving directed energy beam weapons, both ground and space based. The idea was greeted in Britain and throughout most of Europe with scepticism amounting at times to scornful dismissal.

The reason is not far to seek. Europe has shown little interest in ballistic missile defence or the high technology that could produce what President Reagan called "the means of rendering those nuclear weapons impotent or obsolete." Europe is about twenty years behind the United States and the Soviet Union in space technology, even though the European Space Agency has at last embarked on a modest space programme. It is hardly surprising, therefore, that suggestions for exploiting new high technology and the advantages of operating in space should have been virtually ignored, or at best opposed, on this side of the Atlantic.

Europe has not yet accepted the logic in current defence thinking that destroying missiles and their nuclear warheads, which destroy people and property, is a viable and greatly to be preferred solution to the problem of defence against nuclear attack, especially by intercontinental and intermediate range nuclear-armed ballistic missiles. There are, of course, those who oppose any form of ballistic missile defence on the grounds that it would be destabilizing and maintain that space should be used only for peaceful purposes. But the harsh reality is that space is already the fourth element in which nations, particularly the two superpowers, are engaged in competition to exploit the advantages of space for military purposes. There would appear to be little possibility of preventing the continued exploration and exploitation of space for military uses, unless we could disinvent the nuclear weapon.

There is always the possibility that agreement will be reached to reduce, or even outlaw, nuclear weapons and to abolish all

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forms of offensive and defensive armaments designed for deployment in space, but there is no sign that such agreements are likely in the immediate future.

Space-based satellites are already deployed in space for civil and military purposes such as command, control and communications (C3), photographic reconnaissance and surveillance including infrared sensors and radar, early warning of missile launch, data on missile testing, meteorological observation, navigation (NAVSTAR global positioning system) and, with the advent of a manned space station, new horizons are opened up. It was only to be expected that, with both superpowers exploiting the advantages of space for various purposes they would turn their attention to anti-satellite systems (ASAT). The Soviet Union has deployed and tested ASAT systems on numerous occasions over the past decade and continues to develop such systems. The United States has yet to deploy an ASAT capability but is conducting tests with various systems including missiles launched from high-flying aircraft.

Europe cannot opt out of the race to achieve a military capability in space, or the acquisition of new high technology weapons for strategic defence against ballistic missiles, whether nuclear or conventionally armed. Directed energy beam weapons must eventually find their way into the inventories of modern armed forces for deployment on the ground and in space. The Soviet Union may well win the race and in so doing transform the nature of the threat facing the NATO alliance.

United States Proposals for Strategic Defence

It has long been a puzzle to professional military strategists that an offensive weapon such as the nuclear armed ballistic missile which has been deployed for more than 25 years (indeed its forerunner, the German V2, was operational in 1944) has so far found no effective counter. Proposals for defence against ballistic missiles were considered in the 1950s, but the technology required was not available at that time to provide a system capable of even point defence. The more exotic systems, high energy lasers and charged and neutral particle directed energy systems were at the laboratory stage. Nevertheless, both the superpowers developed anti-ballistic missile defence systems with strictly limited capability for deployment in defence of national capitals and ICBM silos. In the United States, virtually

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all research and development into ABM systems was frozen on the orders of Mr. Robert McNamara, the Secretary of Defence who, incidentally, was responsible for an attempt to get Britain and France out of the nuclear business altogether. In 1962 in a press interview he described independent nuclear forces as "dangerous and unnecessary," a clear sign that he would do his best to see them eliminated. In November 1962, he persuaded President Kennedy to cancel the air-launched ballistic missile, Skybolt, which Britain had decided to buy to prolong the life of her V-bomber force and had entered into a solemn agreement with the United States Strategic Air Command for the simultaneous acquisition of the weapon.

In December 1962, Skybolt was cancelled. Britain had no plans for any other system and amidst a political storm on both sides of the Atlantic, Britain accepted an offer of Polaris submarine missiles to be fitted to British-built submarines. McNamara insisted, however, that a clause be inserted into the Nassau agreement assigning Britain's Polaris force to NATO. Today, the force consists of four Polaris submarines of which it is possible to guarantee only one on station at any given time. France made a very different decision and developed her own triad of silo-based, submarine-launched missiles and strategic bombers. If and when the Soviets develop and deploy a ballistic missile defence system, the consequences for Britain will be enormous.

By 1969, when the Strategic Arms Limitations Talks began, both the superpowers had very limited BMD capability. The United States had a system known as Safeguard with associated perimeter acquisition radars and missile launch radars, a long-range interceptor called Spartan and a short-range hypersonic missile called Sprint. The system was never deployed operationally. The Soviet Union deployed an ABM system known as Galosh, around Moscow, which they have continued to improve in performance over the past decade. Neither system would provide a fully effective BMD capability against a large-scale missile attack even in a point of defence role.

The 1972 SALT I agreement on offensive weapons was accompanied by an anti-ballistic missile treaty (ABM) which limited the number of launchers and interceptor missiles which each side could deploy and the type and number of associated radars. The treaty also prohibits the development, testing and deployment of ballistic missile defences that are sea-based,

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mobile land-based or space-based. It also places restrictions on the development and deployment of future systems such as lasers. It did not define the characteristics of missile defence radars or limit the conversion and up-grading of air defence capability to provide a measure of defence against ballistic missiles, an omission which the Soviets have blatantly exploited.

Since the ABM treaty was signed in May 1972, the Soviet Union has deployed new, mobile phased-array radars and hypersonic interceptor missiles and expanded the missile defences around Moscow. At the same time they have been particularly active in high technology research into ballistic missile defence and anti-satellite capability. They have already developed, tested and deployed an ASAT system in space and demonstrated its effectiveness.

The United States has had under development for some years a low altitude defence system designed to intercept incoming reentry vehicles at the lower levels of their trajectory, using nuclear or conventionally armed interceptor missiles, with the aim of providing some protection for missile silos.

Boost Intercept the Best Answer

It has long been recognized that the only really effective BMD system is one capable of intercepting enemy ICBMs or IRBMs in the boost phase, minutes after launch, when they are most vulnerable. This should be supported by a mid-course and terminal system to take care of leakage of missiles or reentry vehicles – in other words a layered ballistic missile defence system catering for exoatmospheric and endoatmospheric interception. The system would use non-nuclear destruct warheads or directed energy beams and would be both ground and space-based.

The world strategic situation has changed since the 1972 ABM treaty was signed. Intelligence analysis of Soviet research and development at their Saryshagan, Semniplatinsk and Golvinno establishments confirms that they are developing high-energy laser, charged and neutral particle-beam weapons and microwave and plasma systems for deployment as ground and space-based defensive systems against both ballistic missiles and aircraft. It is possible that the Soviets are ahead of the United States in the development of these exotic weapons

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systems. It is known that they have tested a high-energy laser against one of their ICBMs and against aircraft and missiles using infrared sensors. It should come as no surprise to the West if the Soviet Union climaxed the Soyus/Salut-7 space programme with the announcement that they have developed a space-based laser or charged particle beam weapon system, probably well before the end of the decade. If they succeed, it will introduce a serious destabilizing factor into the world balance of power equation.

The United States has also tested a high energy laser weapon against drones, anti-tank and air-to-air missiles, but has not yet tested either a ground-based or space-based weapon against an ICBM or even an ASAT system. Europe has so far taken no part in any research in this important arena of military affairs. No European NATO countries were involved in the SALT negotiations or the ABM treaty, not even Britain and France, although they both have nuclear forces. It is only recently, in the course of the intermediate range nuclear force negotiations in Geneva, that the French and British nuclear forces have been recognized and only then as a ploy by the Soviet Union to further complicate the discussions. It is against this background that European NATO countries must consider their attitude to United States proposals for the development and deployment of strategic missile defences. They must decide whether any or all of them should contribute technically and financially to the development of projects recently approved by the Reagan administration which could provide defence against ICBMs and IRBMs such as the SS-20 and SS-22. There can be no doubt that it is in Europe's interests to do so.

The deployment of an effective ballistic missile defence system by both sides would, of course, greatly reduce the threat of nuclear attack and provide a better basis for arms reduction negotiations in which the problem of verification would be less important. The Soviets are feverishly pursuing a policy of defence against ballistic missiles, cruise missile and manned aircraft nuclear attack, coupled with a civil defence policy which would so reduce the effects of nuclear attack against them that their forces would be sure of victory and the Soviet Union would survive attack at any level. Dr. Edward Teller, commenting on the possibility of providing an effective defence against ballistic missiles which developments in high

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technology have made possible, described it as the most important military break-through since the atomic bomb. To the informed military strategists who has watched the unchallenged superiority of the offensive ballistic missile for more than 25 years, the creation of such a defence system would transform the military scene.

The State of the Art in Ballistic Missile Defence

When the United States Safeguard ABM system was put in cold storage in 1972, little was heard of the prospects for a ballistic missile defence system until the subject was resurrected by a non-governmental organization headed by Lt. General Danial Graham and a small team of military experts which became known as High Frontier. They recognized that technological progress in the decade since 1972, had provided the means by which an effective non-nuclear defence against ballistic missiles attacking United States ICBM silos could be developed using technology already available. A nation-wide defence was still not possible, but progress in computer technology, microprocessing and developments in laser, charged particle beams and microwave systems had brought such defence within the bounds of possibility. The testing of Soviet ASAT systems in space indicated a developing threat to United States military satellites from conventional or directed energy weapons deployed in space which blind reconnaissance and early warning satellites on which United States strategic nuclear forces depend if they are to maintain a credible deterrent.

While informed scientific opinion recognized that the most effective ballistic missile defence system would be a layered system capable of attacking ballistic missiles in the boost, post-boost and terminal phases of the trajectory, high energy directed beams were not likely to be available until probably the end of the decade. The High Frontier team cut through the academic verbiage that so often accompanies any new concepts in military strategy or developments in weapons systems and produced a study showing how an effective BMD system could be produced with existing technology until more advanced systems were available. It was sufficient to galvanize the administration into serious study of the whole concept of BMD. The report of the Defence Technology Study Team is the result.

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The High Frontier team had recommended a conventional ballistic missile defence system involving multiple satellites using kinetic energy pellets as the kill mechanism against missiles on their trajectories through space, augmented by point defence systems to defend against reentry vehicles in the terminal phases of their trajectories. A committee on National Space Policy considered the state of the art in BMD, and the options open to the President, and recommended that the United States should, as a matter of urgency, develop space and ground-based defence systems against ballistic missile attack.

Technologically feasible options for BMD were recommended by the Defence Technology Study Team in November, 1983. Their report pointed out what had been known for some time that the destruction of ICBMs in the boost phase of their flight is the ideal in any BMD system, but until recently the technology to achieve boost phase or mid-course interception simply was not available. The Safeguard ABM system of the 1960s, developed but never deployed, had a limited capability against ballistic missiles in the final stages of their trajectory (endoatmospheric but little or none in the mid-course space phase (exoatomospheric).

The Defence Technology Study Team advocates a layered defence capability which would have a boost and post-boost destruct mechanism and a terminal phase defence to limit any leakage of nuclear-armed reentry vehicles into the atmosphere on the terminal phase of their trajectories. Each layer would employ different technologies for acquisition, tracking, identification, aiming and interception with selected kill mechanisms.

Briefly, a layered BMD system would consist of boost phase interception by deployment of sensors that could detect and track ballistic missiles from the moment of ignition to post-boost burn-out in the first 2 to 5 minutes of trajectory. Interception and destruction could be achieved by one of a number of kinetic energy kill mechanisms such as a space-based electro-magnetic railgun firing hyper-velocity small projectiles. High energy lasers, charged particle beams and microwave systems would be more effective but are not jet developed and may take up to ten years to become operational. Power supplies for direct energy weapons could be provided by compact nuclear reactors which are being developed now.

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Mid-course acquisition, tracking, identification and weapon aiming present different problems in that it becomes necessary to deal with individual reentry vehicles released from the missiles which have much smaller signatures than missiles in the boost phase. The technology to achieve this is now within the state of the art, including the ability to discriminate between decoys, debris and genuine warheads. Kinetic energy kill mechanisms can be applied to this phase until directed energy beams become available. Multiple satellite space platforms could be deployed to accommodate the interception and kill mechanisms.

Terminal defence by mobile interceptor launchers with sensors capable of filtering out decoys at altitudes up to 80 miles would require interceptor missiles to be committed to each threatening object and be capable to homing on to an object to release low yield nuclear warheads or kinetic energy pellets.

To produce a fully effective layered defence such as that outlined above requires a great deal of research and development. The United States has already allocated about 2 billion dollars to the project and a bill is now before the Senate which would create a unified space command for the direction of all ground and space-based strategic defence activity. A new agency would be established to coordinate research into direct energy technology on similar lines to the Defence Nuclear Agency. The problems still to be overcome in designing, developing and deploying an effective layered defence system against ballistic missiles are formidable but no longer impossible of achievement.

One promising approach to the problem might be the creation of a programme similar to the Manhattan project which would pursue multiple parallel research into various technologies in which European countries could participate with finance and technological input. But they would have to be convinced that such a programme would be of direct benefit to them, would reduce or nullify the threat of nuclear attack, which today is more menacing than ever before. They must be assured that the policy of mutual assured destruction can be replaced by one of assured survival and in the process reduce the threat of war, nuclear or conventional. European countries, particularly Britain, France and West Germany, have the technological knowledge to contribute to a Manhattan type pro-

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gramme even though they have not so far been engaged in research into ballistic missile defence at any level.

Europe and Strategic Defence

The approach to ballistic missile defence proposed by High Frontier and expanded to a more ambitious programme by the recommendations of the Defence Technology Study Team, would provide defence against all ballistic missiles, ICBMs, IRBMs and even short-range missile attack. The NATO alliance could thus be protected by a space-based and forward deployed ground-based defence system, even though the trajectories and time of flight of medium-range and short-range missiles such as the SS-20 and SS-22 missiles are very different from the ICBMs targetted on the United States.

NATO should need no persuading of the incontrovertible evidence that the Soviet Union is feverishly pursuing a policy designed to provide a space/ground-based strategic defence system before the end of this decade. If both superpowers deployed strategic defence systems there would be a degree of symmetry, but if the Soviets alone are permitted to deploy such a system, the threat to Europe of both nuclear and conventional war would be greatly increased. It is not possible to roll back the tide of technological development, but where research can lead to high technology defensive systems rather than yet more offensive systems which bring with them the corollary of pre-emptive strike or launch on warning, the former should now be preferred.

Two European countries, Britain and France, have strategic and tactical nuclear forces. Britain's strategic nuclear force consists of four Polaris submarines of which it is possible to guarantee only one on station at any given time. The force is assigned to NATO under the terms of the 1962 Nassau agreement. As a replacement for this small force, which the British Prime Minister has described as 'a last resort force,' Britain has opted for the vastly expensive United States Trident 2 (D5) submarine system for deployment in the mid-1990s. France has a triad force of silo-based, submarine-launched missiles and a bomber force. The force is entirely French and is under national control. Even so, no one dissents from the view that NATO operates mainly under the United States nuclear umbrella and most of the theatre and battlefield nuclear weapons are provided by the United States.

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If the Soviet Union succeeds in producing an effective ballistic missile defence system by the end of the decade or in the mid-1990s, Britain's small strategic nuclear force will be nullified, even if it survives political decisions in the coming years. There is no British weapon system under development that could replace Trident in ten years time. France would still have her bomber force, probably equipped with advanced cruise missiles or stand-off weapons, or submarine-launched cruise missiles, but their capability would be insignificant by comparison with the United States or Soviet systems.

From the British point of view, it would make strategic sense to seek a cheaper replacement for the Polaris force, if indeed a replacement is really needed, and divert some of the ten billion pounds from the proposed Trident programme to the United States sponsored ballistic missile defence project. The existing Polaris force could be allowed to continue until the mid-1990s and possibly beyond, by which time it will have been made obsolete by Soviet developments in ballistic missile defence or by new developments in anti-submarine warfare. On all counts, therefore, it would be in the interests of all European NATO countries to promote the creation of a ballistic missile defence system which would not only defend Europe against all types of ballistic missiles, but would make the task of reducing or eliminating the very real threat of attack by nuclear armed SS-20 and SS-22 missiles that much easier.

How Europe Could Contribute to a BMD System

No European country has so far engaged in any form of research into ballistic missile defence. The European space programme is extremely modest and trails well behind the United States and the Soviet Union, so there is little hope of European NATO countries, individually or collectively, devoting the financial resources that would be required to develop a defense against ballistic missiles targeted on Europe. Efforts to persuade them to increase their defence budgets by just 1% over the 3% agreed as an annual contribution up to 1986 has not been met, and Britain has already announced that she will no longer meet even the 3% beyond 1985. A credible defence system could only be achieved in cooperation with the United States.

The requirements for a European defence system, or more

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accurately a system to defend against medium range and short range ballistic missiles, are somewhat different from those sought for defence against ICBMs, with which the United States is primarily concerned. Soviet missiles such as the SS-20 are mobile and could be launched from forward sites in the Warsaw Pact countries on a steep trajectory giving a time of flight from launch to impact of four to six minutes on targets in West Germany. Defence against such attack would require boost-phase acquisition, tracking, identification, weapon aiming and destruction in a very short time scale compared with the 30 minutes for ICBM interception on boost, post-boost and terminal phases of trajectory. In a programme such as the Manhattan project, European nations could undertake research into various aspects of the problem. They may not have the unrivalled experience of the United States in this field, but in computer technology, microprocessing and sensor development they could engage in a joint venture with the United States to speed the process of development of a ballistic missile defence.

NATO Strategy of Flexible Response and Forward Defence

The capability to nullify Soviet ballistic missile attack on Europe would have a profound effect on current NATO strategy, relying as it does on the early use of nuclear weapons in the event that conventional forces could not halt a Soviet assault on Western Europe. This pre-supposes that an initial Soviet attack would be conventional, which it might not be, bearing in mind Soviet doctrine for the employment of nuclear weapons in a war in Europe. NATO would, of course, have to maintain a nuclear capability as part of deterrent strategy to war at any level and the need to strengthen conventional forces would remain. But the development and deployment of directed energy weapons, lasers and charged particle beams, for space and ground-based defence against ballistic missiles and conventional offensive weapons for use on the battlefield and in support of first echelon forces, would reduce the requirement for nuclear weapons and greatly strengthen the capability of conventional forces.

The present strategy of flexible response is losing credibility and needs to be updated. The prospects for arms control in INF and START negotiations are not encouraging. A concerted effort to achieve deployable defensive systems using new high

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technology offers perhaps the only viable alternative to a continuation of the nuclear arms race. The Soviet doctrine for an attack on Western Europe stresses the role of nuclear weapons in the opening phases of an assault in which SS-20, SS-22 and SS-23 missiles, in addition to aircraft-delivered warheads and nuclear artillery, would play a vital part. The ability to neutralize these forces would compel the Soviets to change their doctrine and tactics for a war in Europe. At present, it is reasonable to assume that in a first stike anything up to 90% of NATO land-based nuclear missiles could be neutralized. As a first phase in a European directed energy programme NATO countries should embark on a project to create and deploy directed energy weapons on the central front to defend against short-range ballistic missiles and aircraft, while contributing to a larger programme of defence against longer range missiles in cooperation with the United States.

A programme to develop and deploy an effective ballistic missile defence system for the defence of Europe would involve a significant re-appraisal of current national strategies, especially those of Britain and West Germany, and of NATO strategy. All NATO countries have shown a remarkable reluctance to implement an agreed policy of increasing defence budgets to provide an annual 3% increase up to 1986. It is doubtful whether they would consider budgeting for a ballistic missile defence system if it means an additional financial commitment beyond what they have already accepted.

As a first step, therefore, a small coordinating committee should be established to examine in the light of the technology available whether a ballistic missile defence system could be considered as an alternative to other suggested programmes to improve NATO's defence capability. It would seem to be in NATO's interests to support a new concept of defence with weapons that are capable of "rendering nuclear weapons impotent and obsolete."

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EUROPE AND BALLISTIC MISSILE DEFENSE

By J.L. Janssen van Raay

In the very old days, unlimited blood-revenge was an accepted retaliation to an act of injustice: you rape and kill a woman of my tribe; we annihilate all men, cattle, women and children of your tribe, and burn down your whole village. Many people consider the commandment of the Old Testament "an eye for an eye, a tooth for a tooth" as a cruel, and even barbaric, rule of revenge. In fact it was an important humanitarian breakthrough, meant to reduce the unlimited blood-revenge to an acceptable level: if a tribe kills one of you, kill one of them, but do not destroy their whole village. Of course, since the New Testament, the rule "an eye for an eye, a tooth for a tooth" has also come to be regarded in civilized society as too drastic, and the old system of private penal sanctions has since been replaced by the modern police force, court system, and criminal code.

A second example of change has been the abolition of mass killing as a preventive measure. Of these preventive mass killings both the Old Testament as well as the New Testament offer famous examples: The order of the Pharaoh to the two midwives to kill all newly-born Jewish boys, resulted in young Moses drifting down the Nile in his ark of bullrushes (Exodus 2:3). And with regard to the New Testament one cannot visit a museum in Europe without seeing at least one painting of the massacre of Jewish males, ordered by Herod as a preventive measure against the fulfillment of the prophecy of the coming of the Messiah.

Today one can safely say that unlimited blood-revenge and preventive mass killing violate contemporary Christian principles.

The reader, who has had the patience to suffer me until this moment may wonder whether he is mistakenly reading an article on theology instead of on security. However, the connection between religious thinking and security is clear since religious thought is one of the main sources of inspiration behind the European peace movements with their mass demon-

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strations, sit-ins and attacks on cruise-missile sites.

Let me put it this way: the cornerstone of today's Western defense, Mutual Assured Destruction, is based on unlimited blood-revenge, and also opens the possibility of massive preventive killing, both on a scale impossible in the times of the Old and New Testaments.

Now let me get one thing straight from the beginning: the writer of this article is neither a pacifist nor an advocate of unilateral disarmament. One-sided disarmament measures are disastrous and would certainly lead to an apocalyptic Third World War. As long as there is no viable alternative, we have to stick to the present NATO defense strategy. As long as there is no viable alternative, we have to choose between two evils, and MAD is obviously the lesser one.

To me the a idea of High Frontier defense system is attractive not simply because of its clear military advantages, but because it would bring Western defense into line with fundamental Christian doctrines, and in doing so bring to an end the impossible, soul-tearing dilemma of MAD, and vitiate moral objections to MAD raised by Christian pacifist groups. If, indeed, it would be possible to intercept missiles instead of destroying cities, the moral advantages would be so paramount that consequential minor problems must be solved. Who can object to such a program?

In the first place are those who have ridiculed President Reagan's famous speech, in which he introduced the idea of the High Frontier, as unrealistic science fiction, an irresponsible kind of "star wars." These people do not understand the seriousness of the President's position and the revolutionary dimensions of hope and peace to which he points.

In the second place, there are the pacifists who, for purportedly respectable reasons, reject any possibility of using space for military purposes. These two incongruous groups, of mockers on the one hand and of the idealists on the other, are impossible to convince, so we should save ourselves the trouble of trying to do so.

This is not the case with the European defenders of the traditional NATO strategy. They have pointed to a serious problem of European defense. Until now, the U.S. nuclear umbrella supposedly protected Western Europe not only against a Soviet nuclear attack, but also against a conventional one. It is of course true that the credibility of an atomic nuclear U.S.

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response to a prolonged and successful Soviet conventional attack has been somewhat undermined, not least by Henry Kissinger's famous speech in Antwerp, but the possibility of a U.S. nuclear reaction still has sufficient preventive impact. If both the U.S. and the U.S.S.R. had an anti-missile satellite system in space, Western Europe would have to defend itself conventionally against a conventional Soviet attack. In other words the supportive interrelationship between the U.S. and European security systems would be jeopardized in the event of conventional warfare.

This means that politicians and strategists have to formulate new options and confront the European electorates with them: do you really want to be rid of the nuclear threat of total destruction? If so, you have to pay the price for it. The price is sufficient conventional defense against a conventional attack.

Summarizing, I would like to point out that President Reagan's High Frontier project opens the possibility of negating pacifist objections by bringing Western security needs in accord with Christian morality demanding on defense, not revenge. For this reason Europe should give support to High Frontier. The U.S., on the other hand, should understand European anxieties insofar as the coupling of the U.S. and European security systems is under pressure, and how the need for strengthened conventional defenses tends to raise electoral objections. A joint effort, possibly along the line of Bernard Rogers' plans for advanced conventional systems for the defense of Western Europe, is indispensable. Once this is accepted, the concept of High Frontier can serve to unify, rather than disrupt, the transatlantic alliance.

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SECURITY IN THE NUCLEAR AGE: A NEW STRATEGY IN SPACE

By Robert C. Richardson, III

The salvation and future of the free enterprise system lies in space. The snowballing population bomb can only lead to more regulation and more government. Space can provide energy — from solar powered satellites — and a source of critical materials. Taxes levied on non-government managed telecommunications activities in space are more than paying for the R&D invested in these today. But, a prerequisite to major long-term free enterprise investments in any area is security.

Today, most of our international communications depend on satellites. The taxes derived this year from the communication industries involved in these exceeds the entire U.S. investment in their development and deployment. In brief, we are now getting 100% returns yearly on investment. Were the Soviets to achieve the ability to shut these down, or even threaten to do so, what would be our response if we could not defend our space systems? Would we launch WW III, with a massive nuclear retaliation?

Unless we provide security for the non-military exploitation of space, the money needed will not be provided. It's that simple. NATO was created to provide the security barrier behind which the economies of Europe could be rebuilt. Space defenses are the first essential steps in providing the security essential to free enterprise's entry into this new arena.

Until now, space has been exploited only for support systems such as communications, reconnaissance, navigation, etc. Moving a major defensive capability into space will have the same repercussions on strategy and defense forces, in the long term, like books like Clausewitz's and Douhet's did in their time. In the early 1920s, General Mitchell's demonstration that aircraft could sink battleships brought an end to the supremacy of seapower. Today, High Frontier and the resulting Reagan Strategic Defense Initiative (SDI) will, in retrospect, be credited with ushering in the end of supremacy of Control of the Air.

For the foreseeable future, control of access to and from

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space will become a prerequisite to success in global war. Initial operations in any such wars thus will seek first to deny access to earth from space with ASAT weaponry, then to deny access into or through space with space-based defense weapons, and finally to exploit control of near space to destroy the opponent's ability to continue the war.

The following trends and changes in the world wide environment that affect the security plans and programs of Free World countries need to be enumerated, since they are the driving factors behind the need to now abandon MAD and adopt a High Frontier-Star Wars approach to the security of the non-communist world:

— The shift in the strategic nuclear balance in favor of the Soviets.

— The dramatic improvement in the accuracy of long and medium range ballistic missiles in recent years.

— The increasing cost of conventional forces and new weapons, and the resulting inability to acquire them in adequate quantities, or quickly enough in wartime, to sustain any successful conventional war of attrition.

— Increasing public resistance to dependence on retaliatory nuclear firepower for national security at any level.

— The advent of satellite surveillance which, as it improves, puts at risk the survival of previously secure forces – such as naval forces, shipping, concealed and camouflaged elements, landing of reinforcements, etc.

— Space technology which is rapidly approaching a level of capability that could permit the Soviets to achieve military control over access to or from near space in this century if not countered by U.S. and Allied military space programs.

Based on the above trends, changes, and developments, we in High Frontier and other SDI advocates concluded several years ago that:

The U.S. strategy of MAD could no longer provide an acceptable level of security for the U.S., or its major Allies, from a Soviet first strike.

The combination of national and NATO forces in Europe, as now constituted and sustainable, can no longer provide an acceptable level of security from any major conventional or nuclear attack against Europe.

Soviet space activities, if not effectively countered, will

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constitute a major threat to Free World security. Control of the "high ground" of space would give the Soviets not only military, but also economic dominance as Free World forces and economies become rapidly more and more dependent upon space-based support.

Therefore, we decided that a "New Approach" to Western security was required.

The Proposed New Approach

This recognition of the need for a "New Approach" to the long-term security of the U.S. and of its major Allies led to the High Frontier proposal and subsequently to President Reagan's announcement of March 23, 1983, that he intended to abandon MAD and move to a new strategy of Assured Survival.

When, in 1981, it became apparent that the growing gap in strategic nuclear capabilities, and the resulting shift in the military balance between the U.S. and the USSR, could not be arrested, let alone reversed, by merely throwing money at the defense sector, a small group of concerned Americans decided to set up and fund High Frontier to evaluate a proposed alternative, i.e., defenses instead of trying to throw more and more money at existing categories of weaponry in a futile effort to maintain rough military equivalence under MAD.

Lt. Gen. Dan Graham had proposed the High Frontier approach to achieving Peace Through Strength in an article published in the *U.S. Strategic Review* in the summer of 1981. In the same issue, I explained how Gen. Eisenhower had used a change in strategy to solve NATO's inability to match Soviet conventional mass in the early 1950s. High Frontier was established as an ad hoc industry-expert group under Gen. Graham's direction in the fall of 1981 and completed its first Report in March of 1982.

The High Frontier plan called for the adoption of a new strategy, Assured Survival, that would replace MAD and exploit the Free World's technological advantages to "end run" Soviet superior mass in all types of forces, but especially in offensive nuclear weaponry. It would have us build defenses that would not only protect our peoples and forces in the event of war, and insure U.S. access to space for the foreseeable future, but that would also reduce the utility of the Soviet strategic build up, thereby eliminating the need to try to match it quantitatively.

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The concept calls for building a layered defense against Soviet missiles with two main space-based screens and a point defense for critical hard targets such as the MX. The plan selected a non-nuclear, and initially non-laser, space-based ICBM kill capability using existing technologies. Such a system could be deployed in this decade and would be reasonably acceptable to those that are concerned about increasing dependence on nuclear weapons.

The key factor in the effectiveness of any such defense is that it is the product of the effectiveness of the various layers involved. We would like to get enemy missiles in their holes. If we can't do that, we get them on the rise. Those we miss on the rise we try to get in mid-course. Those that still get through to vital hard targets are to be dealt with by point defenses where they re-enter. Finally, we must cope with any missiles that pass all these screens through passive measures such as hardening, mobility concealment, and civil defenses. This is self-evident to military people, but critics of SDI and High Frontier consistently attempt to judge the proposal's effectiveness on the basis of that of each individual screen, and then argue that these can never be 100% effective; hence the overall plan is termed useless! As stupid as that reasoning may seem, you would be surprised how much time we spend explaining this to critical audiences.

Some Technical Considerations

Let's look very briefly at the technological prospects of implementing a strategy of Assured Survival in our time.

There is a clear consensus among the scientists and engineers that have recently studied this plan, both in High Frontier and in our Defense Department, that a highly effective anti-missile defensive system along the lines I described can now be built, given a political decision to do so and the necessary priorities and funding. There is also a high level of expert agreement that this can be done within this decade, with good prospects of a leakage rate of under 2%, if we are willing to accept reasonable technical risks and first-generation systems based on technology now in hand.

The debate on alternative approaches to missile kill systems divides itself among the pro-laser people, the kinetic energy weapon people, and some proponents of nuclear-driven laser systems.

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Both High Frontier and the President's proposal rule out any deployment of nuclear-driven systems, for political and safety reasons, if not technical ones. There is no question of using these. We will continue, of course, to research them in the event the Soviets were to initiate their use, but these systems, regardless of their merit from a purely technical point of view, are not envisaged in any present plans that I know of to implement the President's proposal. This should be clearly understood.

Once industry discovered defensive system proposals were acceptable, they came up with numerous variants. Which are the best and should be developed is still under debate, but an interesting finding is the heretofore unappreciated potential that all the new micro systems and "smart weapons" technology offers to space-based intercept capabilities. Some of those who have studied this tell me that they have yet to find the bottom of how small they can get in effective tracking, acquisitions, and guidance systems for space-based kill vehicles.

While many experts have worked for years on smart weapons in tactical warfare roles, their application to space defense systems had not really been considered even in the High Frontier study. This suggests exciting new possibilities in cost, weight, packaging, and similar factors helpful for weaponry that has to be boostered into orbit.

Whether or not a laser kill ability would be sought in a first generation system probably depends upon timing. High Frontier eliminated lasers from its proposal because the preponderance of experts consulted could not promise them in the time frame of six or less years we aimed at in 1982. They did not meet the criteria of available technology, at least two years ago. Given the loss of time that has already occurred, and likelihood of a less than crash program, lasers may be ready for first generation systems. Our position in High Frontier does not oppose these, but merely argues that we should not wait to build the Model A car until Cruise Control is ready!

We in High Frontier argue that time is of essence, both due to the current Soviet threat and to save costs. Our studies have shown that we have to add about 30% per year to the total costs of major new weapons programs for every year added to their development cycle.

We have seen numerous kinetic energy kill concepts that appear acceptable for a first generation system. These involve IR and optics and would either impact the booster or scatter

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some form of shrapnel to do this. We do not need very expensive or sophisticated systems just because they are to be space-based.

The point defense approach High Frontier recommended was interesting in that it differs from that conceptually pursued to date by most of our ballistic missile research programs.

Until very recently, those researching ABM systems in the U.S., that is mainly the Ballistic Missile Defense organization of the Army (BMD), pursued concepts such as SENTINEL and LOADS which seek to protect, at a minimum, an entire missile site or air field, rather than just one small, hardened, point target like a single missile silo. This led to costly and complex systems, offset from the targets to be defended, and that required large acquisition radars whose vulnerability was often the Achilles heel of the defenses. Since they sought to kill the incoming warheads at great distances, they also tended to opt for nuclear warheads.

The High Frontier concept introduced the notion that since area protection would be provided by the space-based layers, all we were interested in for the point defense layer was protection for critical hard targets such as ICBM silos, and then only against leakage through the space layers.

Given this more limited task, and the fact that we would be protecting against leakage and not a hailstorm of warheads, we looked upon the missile defense as comparable to the tail gunner on a bomber. (If the warhead was not headed close enough to each specific missile or bomber to damage it, ignore it.) This allowed us to look at system proposals that broke up the warheads headed our way quite close to the targets, where they had to be in a very narrow corridor, and hence were vulnerable to non-nuclear systems.

Exactly which of the numerous approaches suggested by industry will eventually be adopted to one yet knows. In 1982 we thought Tracor's SWARMJET was attractive since it could be fielded in less than two years, and relatively cheaply. Since then, versions ot the General Electric Corporation's GAU-8, now being bought by NATO for ship defenses, as well as several other weapon systems proposed by industry in the aftermath of the President's speech, may well be even more attractive. All of these proposals were addressed in the Fletcher Commission Report, or will be sorted out by General Abrahamson's new office responsible for SDI.

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Some Key Advantages to Assured Survival

The proposed strategy can be implemented without building additonal nuclear weapons, and once in place may even permit reducing some nuclear offensive capabilities. This should obviously please those concerned about increasing dependence on nuclear systems for the future security of the West.

Assured Survival, unlike MAD, is militarily sound. The proper role of the military has always been to defend the country against aggression, not merely to avenge it. Security based solely on hoping to deter aggression by maintaining a Balance of Terror has never made military sense.

Strategic defenses can protect against both accidental and intentional or terrorist launchings. Given the likelihood of nuclear proliferation, today's choice of passively accepting thousands of casualties or starting WWIII by retaliating in kind when faced with such events is both unacceptable and irrational.

Implementing the new strategy is probably the best way to ensure availability of U.S. funds for NATO and other general purpose forces and limited war missions in out years. This is important, for some in Europe seem to fear that SDI will lead to a "Fortress America" attitude or to less U.S. funds for NATO defenses. Actually, the contrary is far more likely.

So long as the strategic nuclear imbalance constitutes the main threat to America, it will be a priority concern. Therefore, unless it can be dealt with inexpensively, as will be the case given Assured Survival, it will be done expensively by building more and more offensive nuclear systems and multi-billion dollar passive survival schemes such as the 200 MXs and the previously proposed Multiple Shelter scheme which were deemed necessary to perpetuate MAD even under the Carter Administration. These would almost certainly be at the expense of spending for other military forces.

Defenses against ICBMs are politically acceptable. We found, in over a year of press conferences, TV showings, articles, and debates, that the American people want to be defended; that they reject MAD as immoral if not ineffective now that the strategic balance has shifted to the Soviets; and that the public, at least in the U.S., is not unduly concerned over the likelihood that in the long run the new strategy will require revising the ABM treaty.

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Most thinking people recognize that the ABM treaty was a creature of the MAD strategy and has no rationale if you abandon MAD. Many think that the Soviets have already violated it. They also note with interest, if not some amusement, that Mr. Gromyko proposed strategic defenses as a way to move toward reductions in offensive systems in a speech at the U.N. in 1963! Many think that there are better chances for valid START agreements given defenses on both sides than under today's offensive-only postures. Some arms control authorities have written arguments to this effect, which point out that verfication and cheating lose their critical nature if both sides have defenses.

Strategic defenses pose no threat and can save lives. They can only be deemed provocative, as some have argued, if one assumes a strategic imbalance, even temporarily, by virtue of our acquiring a capability to defeat Soviet ICBMs while they had none to stop any of ours. This is just not in the cards in the real world timing of developments of this nature, given the Soviet defensive capabilities at this time, their proclivity for defenses, and their historic tendency to copy us. As Secretary Weinberger recently pointed out, the odds are in favor of the Soviets coming out with effective anti-ICBM capabilities before we do. Under Assured Survival, offensive nuclear forces could be reduced somewhat, whether or not treaties to do this are agreed upon.

Once we have an optimum balance between active and passive defenses, offensive force requirements can be reduced to levels compatible with the tasks they are to perform. If we can protect the offensive forces we need to retaliate, then we don't have to build and deploy costly redundancy or extra large inventories to insure that enough would survive a first strike, as is now the case. Furthermore, the active defenses will protect not only our ICBMs, but also bombers, carriers, and cruise missiles, all of which are now completely undefended against a first strike.

The most important advantage we in High Frontier see in the implementation of Assured Survival is the elimination of the Balance of Terror that results from the potential for a successful strategic first strike, and the related MAD retaliation capability that substitutes massive salvo responses for the classical graduated application of military force. Assured Survival can return warfare to a Phase I contest of attrition, albeit in space.

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This would eliminate the potential for overkill built into MAD, or the prospect of over-responses to accidential or terrorist launches that might come about.

Given offensive and defensive space-based systems, in being, contestants in any major war would have to deal with these as a matter of first priority. This will turn the Phase I battle into a contest for space control, as was the case for the control of the air in WWII. Since this would, in turn, shift the opening, and probably decisive, engagements away from London, New York, and Moscow, into the arena of space, it would greatly increase stability by buying time for political actions and by postponing, if not eliminating, the need to inflict massive destruction on earth to ensure ultimate survival, if not victory.

Movement of the first phase, decisive, "cutting edge," strategic operations into space will also increase stability in peacetime.

Today's dominant systems are the strategic offensive systems. If an aggressor wipes these out in a first stike, as is possible due to their increasing vulnerability and fixed nature, victory is possible.

ICBMs, being immobile and in generally known locations, can be all targeted in a single, surprise, first strike. No aggressor can destroy a space-wide deployment of satellites in a single strike. This means that the battle for space control must be one of attrition, as was the case for control of the air. This in turn buys time, ensures gradual application of force, and removes the overkill element inherent in any first strike effort against ICBMs. This difference makes for stability and minimizes the prospects of unnecessary nuclear damage.

Satellite based defenses cannot be defeated by the Soviets merely by building more ICBMs, as some have naively suggested. Simple calculations show that the utility of each additional missile declines as defense effectiveness rises. At 90%, the Soviets would have to add ten to get one through. At 99%, they would have to build a hundred to get one on target. Clearly, the costs and critical materials necessary to achieve any reasonable first strike probability of success through saturation of defenses quickly become prohibitive.

Today, when both sides are dependent solely on offensive nuclear delivery systems, either side can calculate what they need to have a high probability of destroying the other's ability to retaliate. Against space-based defenses, they cannot calculate

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either how effective the defenses will be, or what missiles would be intercepted. This makes a first srrike even more risky, and is a major deterrent to a first strike attack.

The U.S. research and industrial effort to build effective anti-ICBM systems, and continue to upgrade them, cannot but have several important side effects. First, we can assume that progress in effective point defenses for hard strategic targets will produce effective point defenses for use in protecting a wide range of potential Soviet targets both in the U.S. and in Europe.

The trunk technologies needed to deploy and support space-based defenses are much the same as those required for other military and non-military space activities. The new strategy will open up numerous other military and non-military possibilities in space to the advantage of the free world and its defenses.

Laser developments, which will be vigorously pursued to improve space-based defenses, no doubt also will generate near-term capabilities to threaten not only missiles in space, but also air-breathing systems and eventually ground targets. This in turn will greatly impact force operations, deployments, and force requirements at all levels.

Major naval forces now at the mercy of the combination of Soviet radar satellites directing ICBM firepower, with no possible passive survivability or point defenses of consequence against ICBM attacks, will greatly benefit from strategic defenses able to negate both the Soviet locating, targeting, and missile threat.

Finally, the prospects for offensive arms reduction agreements should be increased greatly by strategic defenses. Attempts to achieve these in an offense-only MAD environment have failed miserably. Given defenses, the difficult issues of cheating and verification become easier to deal with.

Where Are We Today?

Now where do we stand today?

The President, in March of 1983, directed our Defense Department to establish study groups to investigate the technological possibilities and also to look at other implications of adopting this plan, such as its impact on arms control negotiations, etc. Their reports were submitted last October and their major conclusions have been widely and publicly debated.

High Frontier and its supporters do *not* agree with the

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assumption that several years of research are required before a capability is made. Project Defender proved that space-based anti-ICBM systems could have been built in the 1960s. To say we can't do it today is either foot-dragging or seeking impossible effectiveness levels.

Once the administration took on the task of studying the SDI and its implementing requirements, we in High Frontier indicated we would continue to educate the public as to its advantages, debate the "antis," help get a better Allied understanding of the benefits and implications for them, but not try to compete with DOD in technology – only "blow the whistle" when and where it seemed to us that delaying tactics were being used to protect existing programs, roles, and budgets.

The next big decision that will have to be made will be how and in what manner and time frame the SDI will be implemented. What we hope is that President Reagan will set a date by which he wants the capability deployed; convert, in due course, the SDI research organization under General Abrahamson into a special acquisition organization of the Manhatten Project type; obtain the necessary priorities and funding from the Congress; and proceed to build the systems necessary to truly abandon MAD and defend America and its Free World Allies.

If, instead, the proposed strategic defenses are to be developed in a "business-as-usual," low-risk way, the "Star Wars" label that the press gave to the President's March speech will be validated. The plan will not be perceived as solving the growing strategic gap, and defense and MX basing problems will remain before us.

With respect to the arguments that have been recently advanced against the SDI as a result of the budget battle, we heard them all during our months of public education on the High Frontier plan.

Opposition from people concerned about the impact on the funding of their pet programs or on their job stability – typically arguing not against the plan but for pushing it far out into the future – adds up to nostalgia for MAD and the ABM Treaty by their former architects. That from dedicated disarmament buffs is mainly wishful thinking about keeping the arms race out of space, where it is already and has been for some years now.

The Soviets, of course, object strenuously to the proposed new Western strategy. Even though Mr. Gromyko once pro-

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posed it, as I previously mentioned, it now would frustrate what they had contemplated as a free ride to overall military superiority within this decade. It would make obsolete their massive investment in nuclear missiles and oblige them to compete in an area of technology where they are clearly at a disadvantage — a competition they tried to prevent with the ABM Treaty. So while opposing our building defenses or breaking out of the ABM Treaty, they are working like dogs to accomplish just that for themselves.

Regardless of all the arguments, pro and con, over the proposed new approach to lasting U.S. and NATO security, the real "bottom line," is that our political leaders have, basically, only three alternatives:

> They can accept inceasing Soviet military superiority and pray that from their newly acquired position of military strength the Soviets will agree to arms limitation treaties that will provide security for their people and their countries; or
>
> They can try to maintain rough military equivalence in existing categories of weaponry and under the MAD strategy, which obviously requires that they pursue an arms race building more offensive nuclear weapons with costly passive survival systems and larger conventional forces, as necessary to roughly match the Soviet build up; or
>
> They can do what we now propose, and what NATO did in the 1950s when the West could not afford to match Soviet mass, that is, change strategy (the method of doing the business) and exploit technology to re-establish a military balance at a cost the Alliance can afford. This is essentially what High Frontier and President Reagan propose.

No one that I know of in any of our countries has come up with any other options, only variants of one of the above. Politicians can be either: 1) For inferiority; 2) for more offensive nuclear weapons and defense spending; or, 3) for the change in strategy, or a variant thereof, which we now propose. To quote an old American gambler's expression, the bottom line is that "Star Wars" is "the only game in town."

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THE ECONOMIC AND COMMERCIAL DEVELOPMENT OF SPACE

By Peter E. Glaser

Introduction

> "For most of us the future is the compensation and fulfillment of all that the present and the past have lacked. The future being unknown and incontrovertible has been a fair ground on which to place all our hopes and desires. But in scientific prediction these desires are the most elusive guides. The opposite danger is great and more insidious: In our lives we take the present for granted to an extent far greater than we can realize. Even when we are thinking of the future we cannot separate the historic accidents of the society in which we were born from the axiomatic bases of the universe. Until the last few centuries this inability to see the future except as a continuation of the present prevented any but mystical anticipations of it."

These words of Professor J.D. Bernal in his 1929 essay, "The World, the Flesh, and the Devil," are not only part of an astonishing scientific prophecy but also indicate the constraints on visualizing the future course of events. Such constraints are particularly applicable to the forecasting of new technologies and the growth of commercial ventures in space.

Projections made a quarter of a century ago concerning the many ways in which space activities would affect life on Earth were significantly off the mark. No one today can accurately predict the impacts of space activities over the coming decades. Nevertheless, much is known about the potential of these activities and the benefits that could be derived from them. Space offers us inexhaustible energy, materials, resources and a unique environment; there is little doubt that the future exploitation of these assets will have a profound effect on the global economy.

Technology strongly controls the nature of commercial activities and is the key to economic growth, industrial expansion, national security and international influence. Thus, the

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technical capabilities already demonstrated during the preceding 25 years of space exploration have created a foundation for future commercial enterprises. These activities will affect the next century's international, political and commercial relationships as significantly as airplanes, electronics, computers and communications have shaped the global economy of the present century.

The United States enjoyed the world's highest standard of living as recently as 1970: today, we no longer can claim a clear-cut leadership position. This loss of economic leadership has exacted a heavy price, not only in terms of the American quality of life, but in national prestige and international political influence. The toll on the national psyche has been especially severe. People no longer believe, as an act of faith, that almost anything is possible for the United States and its free enterprise economic system.

No single solution or invention can succeed in reversing that trend. Things are not that simple. But it is apparent that a major transition to a high-technology economy based on innovative products and advanced technologies is essential during the coming decades to forestall a further decline.

There appears to be a correlation between innovation and the leadership position in space technology. For example, in 1970 when the United States was clearly the leader in space exploration, 50% of the world's research and development (R&D) was performed in the United States. This share has declined to about 10%, and the number of scientists and engineers in the U.S. has dropped steadily over the past decade, unlike the situation in other industrialized nations.

Industrial activities in space can provide the impetus needed to renew confidence in the innovative capabilities of U.S. industry. Industrial innovation and renewal, however, depend on reversing the downward trend in the educational system; the U.S. is estimated to have some 30 million functional illiterates. In 1980, Japan graduated 74,000 engineers compared with 58,000 in the United States, which has twice the population. The USSR leads in the number of technical graduates, with India in second place.

The U.S. economy will have to face the challenges implied by the multifaceted transition to high-technology industries. This transition will be essential during the coming decades to maintain competitiveness in world markets, to provide expanding

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opportunities for business ventures, and to serve as a stimulus for concerted actions. The goals associated with the development of commercial activities in space, spearheaded by the space shuttle and leading to a space station, represent evolutionary steps in this direction. The potential for developing human capabilities in space provides the kind of drama that ignites the imagination and that is needed to rekindle the "can do" spirit that not so long ago made the United States the envy of the world.

Today the space shuttle is the key component of an effective transportation system from Earth to low-Earth orbit and return. It will enable scientists and engineers to obtain the data they require to determine which commercial activities are economically feasible. The success of the shuttle also was an essential element in the decision by the U.S. Government to develop a permanently manned space station and to do it within a decade because "space holds enormous potential for commerce today." The space station will have an important role in support of a broad range of scientific and commercial activities, which may be performed either in the space station or in free-flying satellites tended by the space station. The station will permit extensive facilities in orbit to be built-up gradually and equipment to be maintained and repaired, leading to major improvements in capabilities to perform scientific investigations, to manufacture products and to achieve reductions in project costs. It could be a support base for transportation of payloads to higher Earth orbits and eventually provide routine access to the moon and to the planets. The building of a lunar base, where materials could be processed for use in the construction of more extensive space projects in Earth orbits and in support of scientific explorations, would provide a major mission for the space station. This base would give an open-ended aspect to the development and growth of an industrial infrastructure that could support an increasing variety of commercial activities designed to make the most effective use of the inexhaustible energy and material resources of the solar system.

The Solar Power Satellite Concept

Energy experts generally agree that inexhaustible and renewable energy sources will be needed to meet global energy demands in the 21st century. Research to date has identified

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only two promising methods for large-scale, continuous energy conversion, other than nuclear fission, which do not depend on fossil fuels: thermonuclear fusion, and energy converted in space for use on Earth. At present, fusion is under active investigation. There is, however, no concerted research devoted to energy from space. Future economic and geopolitical stability may be influenced by the results of long-term alternative energy R&D programs, so that dependence on the outcome of only the one advanced R&D effort, the fusion program, entails significant risks. Comparative assessments of promising energy conversion methods including energy from space are required to maintain focused energy R&D efforts. In this context, energy from space, using the concept of solar power satellites (SPS), deserves continuing consideration.

The SPS proposed in 1968 to capture the energy radiated by the sun, represents an energy conversion method capable of generating electricity continuously (baseload) on a global scale.(1) Besides providing energy to Earth, the SPS can be a focus for expanding human activities in space.

As currently envisioned, the SPS would be placed in geosynchronous orbit, 22,300 miles above the equator, where solar cell arrays would convert energy from the sun dirctly into electricity and feed it to microwave generators forming part of a transmitting antenna. The antenna would precisely direct a microwave beam of very low power density from the SPS to one or more receiving antennas at desired locations on Earth. At the receiving antennas, the microwave energy would be safely and efficiently reconverted into electricity and then transmitted to users. An SPS system could consist of many orbiting satellites, each beaming power to one or more receiving antennas.

Assessments of the technical, economic, environmental, and societal issues associated with the SPS have not identified any single constraint that would negate the SPS concept.(2) High front-end costs have been cited as a prime reason for delaying even an R&D program.(3) These cost projections assumed a very large-scale program including a commitment to an integrated development and implementation program that could meet 25% of the U.S. electricity demand by 2030, and discounted the evolution of generic technologies. Based on this assumption, the U.S. Department of Energy (DOE) has not proceeded further with the SPS Concept Development and Evaluation Program (CDEP).

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During the early 1970s, when the SPS design was being evolved by NASA(4) for use in the CDEP, the space technologies required were in an early stage of development. Since then, significant advances in a wide range of technologies have been achieved and are being successfully applied to expanding space activities. The growing industrial infrastructure supporting these activities will strongly influence the development of space transportation systems, space stations, and similar space projects of increasing scope and complexity.

The resolution of issues associated with implementation of the SPS including electrical power demand, power network interfaces, load management, receiving antenna siting, availability of material resources, and comparative assessments with other energy conversion methods, was already considered as part of the CDEP, and there is an existing framework for continuing these assessments.

The CDEP program was recognized by DOE as a model for the effective assessment of large-scale energy conversion projects.(5) Although the depth of analysis was limited by the available funding, the studies supporting the program examined an unprecedented variety of issues that might influence development of the SPS. An explicit objective was to involve public interest groups in discussions about the SPS so that future decisions concerning the project could be based on a broad consensus rather than on narrowly defined expert opinion.

SPS designs ranging from 10 MW to 5000 MW have been studied in Canada, Czechoslovakia, England, France, Japan, the Soviet Union, and West Germany, indicating the wide interest in the power generation potential. One reason for the increasing confidence in the technical feasibility of the SPS is that alternative technologies have been identified for nearly all components of the system.

Most studies have been concerned with the SPS reference system which was chosen during the CDEP to provide a common basis for assessments. This "reference system," based on assumed guidelines, was established by NASA to evaluate environmental effects, explore societal concerns, and perform comparative assessments. It is a design concept based on known technologies of the early 1970s; it does not represent a system that was expected to be actually constructed. An operational SPS, which could be developed during the next 20 years, would use some of the many alternative technologies that already have

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been identified for advanced SPS designs and would thus be quite different from the SPS reference system. Just as one aircraft design does not meet all of the requirements of the air transportation industry, SPS designs for different purposes will have to be developed.

Although the SPS does not produce the undesirable environmental effects associated with large-scale fossil and nuclear energy conversion technologies, several areas of potential environmental concern have been identified. These concerns include low level microwave biological effects, heating of the ionosphere by the microwave beam, deposition of rocket engine exhaust products in the upper atmosphere, and interactions of ion thruster propellants with the magnetosphere. Several of these effects are not yet well understood, and a few may have long-term consequences. Therefore, steps to reduce them will have to be explored. Scientific investigations already have indicated that exposure to microwaves at the flux densities estimated to be received at the ground antenna site will not pose hazards to bees and birds. No environmental effects have been identified that a priori preclude continued consideration of the SPS.

The National Academy of Sciences,(6) in its critique of the SPS concluded: "Some type of SPS would be technically possible if costs were not a consideration." This conclusion was reached by focusing on the SPS reference system, which was evolved as a tool for inquiry and included an implementation scenario for 60 satellites placed in operation between 2000 and 2030. This scenario was not a plan of what would or should happen, but was a basis for studies pertaining to space transportation, material resources, and manufacturing requirements. Both the SPS reference system and the scenario for its implementation assumed a "stand-alone" SPS development program.

The Office of Technology Assessment, Congress of the United States, in its report(7) indicated that, when operational, the SPS could be an economically attractive option for power generation. For most advanced technologies, such as fusion and the SPS, uncertainties in cost projections extending several decades into the future considerably exceed the cost differentials that, in practice, will determine their relative competitiveness. For example, both the SPS and fusion are promising technologies, but further research is needed to provide data for

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economic analyses to justify decisions about their development and implementation.

Synergy With Space Technology Developments

The goal of the SPS is to provide an economically viable and environmentally and socially acceptable option for power generation on a scale substantial enough to meet a significant portion of future world energy demands. The concept is based on the extension of known technologies and could stimulate extensive space activities.

Satellites to be built during the next decade will require more electric power than current satellites and could well get their power from a space-based power plant. Such a plant could be modified by the addition of a microwave antenna to transmit power to other satellites. Advances in orbital assembly will increase the feasibility of constructing large structures in space. Development of thin film solar cells has the potential to reduce mass and cost and to achieve the production goals of solar cell arrays for an SPS. Orbital transfer vehicles using chemical propellants, solar electric or microwave electric propulsion are being studied. Only after such generic technologies have been developed and demonstrated would a prototype SPS be designed, constructed, and tested. Advances in space technology may also open such other possibilities as the use of extraterrestrial construction materials to reduce the cost of transporting material to an SPS construction site in orbit.

The SPS represents a fertile field for innovations. Few of the potentially interesting alternative technologies have been analyzed in detail. It would be premature to choose among them because the consequences of these technologies cannot be evaluated without a vigorous system study of the impact of advanced technologies on SPS designs at the system and subsystem levels.

The development of the most effective SPS designs for intended uses represents significant challenges, and these challenges must be met realistically. But it is as inappropriate now to discount the SPS as a major option for the 21st century as it was for Simon Newcomb, American astronomer, to state in 1906 that "the demonstration that no possible combination of known substances, known forms of machinery and

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known forms of force can be united in a practical machine by which man shall fly long distances through the air seems to the writer as complete as it is possible for the demonstration of any physical fact to be."

An Approach to SPS Development

Since its inception, the SPS concept has been controversial, because it brought into focus technical, economic, environmental, and societal issues involving perceptions about the role of space technology, and centralized and decentralized energy conversion options. The SPS has also raised questions about the decision-making process in the face of uncertainties associated with projected system performance and costs, environmental effects, and continuing support of private and public investors.

Criticism of the SPS focused on the fact that it is a large-scale project. Traditionally, a large-scale project is conceived and executed with a definite start date and agreed-upon performance objectives, budgets, and schedules, and with an identifiable management organization responsible for implementation, i.e., a monolithic project. Success or failure of a monolithic project is judged by whether or not the project objectives are met within budget and on schedule. Further, the time needed to complete such large-scale projects makes them vulnerable to changes in the regulatory environment, and, if they extend over a decade or more, possibly to changing economic and political conditions. Any such project requires a continuing consensus between public and private investors, as well as the support of appropriate interest groups and government agencies during the various stages.

The implicit assumption in the CDEP program was that the SPS is a monolithic project requiring a massive commitment of funds over the next several decades. An approach can be devised for the development of the SPS that identifies the underlying generic technologies and their application to specific space projects as shown in Figure 1. The "terracing" of space projects would reduce the challenges typically associated with large-scale projects including control of the project, the effects of technical uncertainties, maintenance of investor confidence, reduction of environmental impacts, and the difficulties associated with termination of the project if warranted. The increasing capabilities needed for planned space projects – free-flying

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carriers, manned space stations, and space transportation systems of higher performance and lower cost – will contribute to the industrial infrastructure that could be the foundation for SPS development.

As shown in the Figure, the SPS is only one potential application of space technology which could evolve form future space projects. However, projects such as the SPS are unlikely to be pursued without stimulation by interests outside the space program.

As part of this approach, increasingly advanced designs for an SPS could be studied in conceptual form. They need not be defined in detail until information from space projects at successive "terrace" levels can guide the evolution of the most appropriate design for the SPS. The designs that employ the most effective generic technologies can be developed, assessed, and analyzed, and the results shared with the participants in the SPS R&D program and with public and private investors.

Essential to the success of the "terracing" approach is an SPS R&D and planning effort. The effort would include:

– Assessment of economic, technical, regulatory, legal, and societal issues associated with the SPS.

– Definition of technologies required for the SPS and their possible development as part of other space projects so as to increase the technology readiness for the SPS, (e.g., space systems, including suitable launch vehicles, orbital construction bases, orbital transfer vehicles, and automated construction equipment).

– Coordination in the use of technologies appropriate for space and energy projects.

– Documentation of efforts to develop technologies for other space projects so that the information obtained, and experience gained can be integrated into the SPS R&D efforts and planning.

The assumption underlying the "terracing" approach is that advanced technologies will be developed in support of existing or planned national and international space projects. For example, some of the technologies that will be required for the SPS are being developed for near-term space applications, including telecommunications, remote sensing, materials processing, and space transportation. Specific technologies are being identified for future applications such as a space station involving on-orbit

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power generation, food service systems, life support equipment, robotics, and data architecture and management.

This approach will be judged successful when technical uncertainties and risks in the SPS program are greatly reduced, the industrial infrastructure is established, and substantial information is available on the technical feasibility, economic viability, and social and environmental acceptability of the SPS designs to the decision makers.

The Near-Term Decisions

The public or private investors in other space projects do not have to commit themselves to the SPS. Each space project must be justified on its own merits. If the decision is made to abandon further consideration of the SPS, these space projects will not be adversely affected because their success is independent of the decision concerning the SPS.

Public support will be sought for specific space projects as well as for the SPS. Economic, environmental, and societal issues of the SPS can be assessed at the R&D stage to provide more time to develop a consensus on these issues, while creating a factual information base.

The "terracing" approach is particularly applicable to the SPS because many of the technologies required for the successful implementation of the SPS are also part national and/or international space programs. The timetable for developing the SPS will strongly depend upon the successful completion of several space projects, including a range of activities to be performed in space stations.

The Rationale for Commercial Activities in Space

Commercial activities in space within the framework of space industrialization could provide valuable new services, projects and processes. However, the latter have not yet been demonstrated, except for telecommunications and, to a limited extent, Earth observations. No hard data have been presented that today would justify most space activities as practical commercial ventures in an accepted business sense. Furthermore, there is certain to be an extended period between the development of industrial activities in space and their commercial exploitation.

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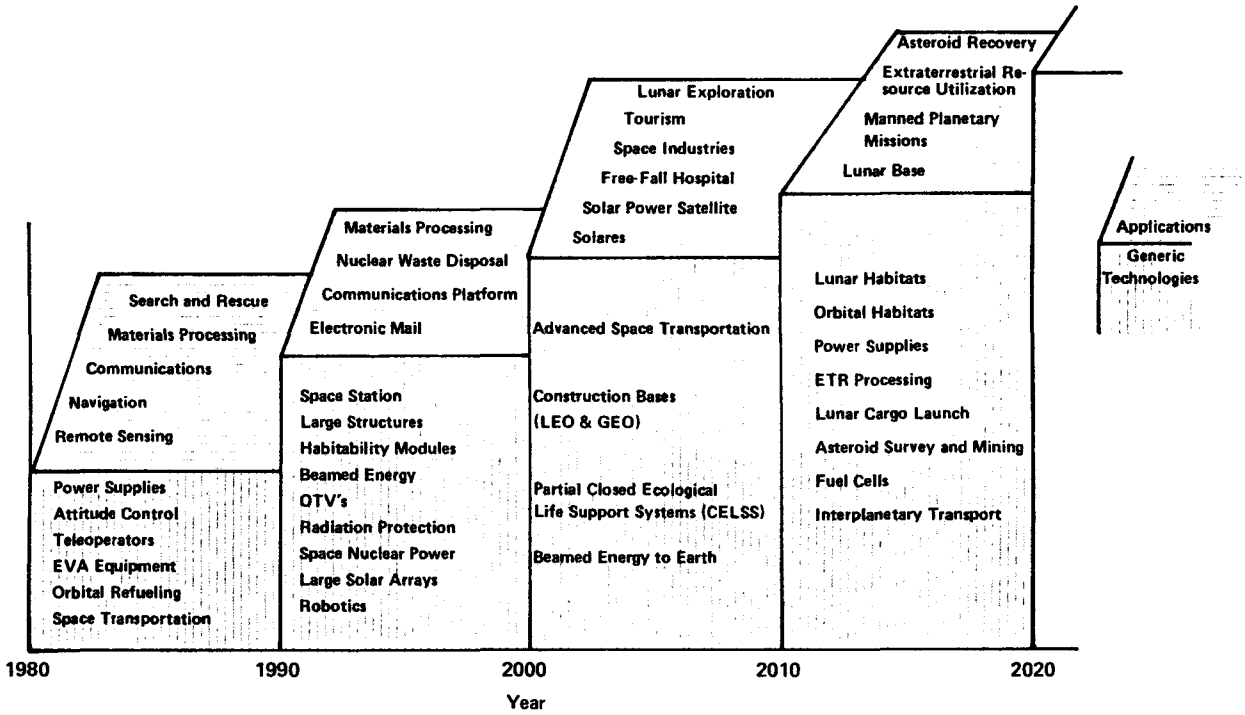
The Terracing Approach



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Investments in space industries must be considered high-risk because neither benefits nor profits can be projected with certainty. With a few notable exceptions, industry is not yet ready to take that risk.

Investors see a credibility and information gap regarding the challenges, costs, risks, and benefits of commercial activities in space. Industry is adopting a "wait and see" attitude, partly because the substantial technical advances of the U.S. space program and their significant potential benefits to the U.S. economy are not widely recognized or even acknowledged, and partly because the prerequisites for commercial activities have not been clearly formulated. Among these prerequisites are:

- A long-range view and global outlook; this is not characteristic of most industrial organizations, nor of the executive and legislative branches of government, where short-term needs and goals predominate.
- Integration of space commercialization with national space policy; this is beginning to happen.
- Approaches to serve national and international space markets; these have not been defined in detail because of considerable uncertainty about the magnitude of these markets.
- Closer industry/government cooperation.
- Creation of institutional structures conducive to commercial space activities.
- Tax incentives to stimulate capital investments in space ventures.
- A legal and regulatory framework for commercial activities in space.
- Investment mechanisms to meet the needs of industry, lenders, investors, and governments.
- Availability of cost-effective space transportation and other supporting space servies, e.g., power, maintenance, food and fuel supplies.

The Competitive Environment

The potential benefits of commercial activities in space have been recognized by many countries. Some of their industries have the advantage of "patient money" and can afford to invest today for the promise of payoff in the long-term future. International competition, motivated by economic and market

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considerations, will be increasingly important to the evolution of these activities. Although not in a position to contribute to space research, Third-world countries are anxious to share in the benefits and are demanding a voice, for example, in the allocation of radio frequency bands, geosynchronous orbit positions, and the use of information obtained from satellites.

The commercial space activities with the greatest promise for near-term economic payoff are the following:

- Telecommunications. (Some 150 participating countries and 120 orbiting satellites represent a $10 billion annual market, which is projected to grow substantially by 2000. These activities are performed within a complex global regulatory framework. The booming telecomunications industry has stimulated organizations in several countries to adopt long-range plans to develop more extensive space capabilities for commercial markets.)
- Remote sensing of mineral resources; monitoring crops, insect infestations, and pollution; and as an aid to urban planning.
- Geologic mapping for cartography, hydrology, and earthquake prediction.
- Navigational satellites.
- Meteorological satellites.

An increasing number of commercial enterprises are pursuing space business opportunities, which range from specific commercial end uses to services for spacecraft operations, including design and production of payloads, payload integration, space transportation and data management.

The challenge confronting industry is to find ways to surmount the lack of sufficient near- and mid-term business volume and to sustain development activities long enough to capture the long-term benefits of space commerce. However, U.S. industry's skepticism about the potential economic return from commercial activities in space is making it reluctant to engage in determined competition in this field. As a result, it may lose by default to other countries who have set their sights on the exploitation of space for commercial purposes. If it expects to be the leader in space commerce, the United States must forge ahead with a broad range of space activities.

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The Space Station

Today's space shuttle is the key component of an effective transportation system from Earth to low-Earth orbit and return. It will enable scientists and engineers to obtain the data they require to determine which commercial activities are economically feasible. The success of the shuttle also was an essential element in the decision by the U.S. Government to develop a permanently manned space station and to do it within a decade.

The space station opens a door for American industry. This will be crucial to the future of U.S. businesses because the successful development of commercial products and services is essential to exploiting "the enormous potential of space commerce." Space commerce will be as significant in determining political and commercial relationships in the twenty-first century as developments in aviation, electronics and computers in the twentieth century are in determining economic growth, industrial expansion and international influence.

The space station will pay off because it is not just a technological challenge. It will be worthwhile because it makes many other projects in space science, telecommunications, manufacturing and exploration possible. It clears the way to tap the inexhaustible energy and material resources of the solar system. It is the next step we are ready to take.

The strategy for commercial activities in a space station will have to be planned and coordinated with long-term space industrialization goals; for example, establishing a lunar base and obtaining energy from space for use on Earth. However, we need not now focus on the long-range goals. Areas of potential commercial interest with near-term benefits are already discernible:

- "Fee-for-service" laboratory where industrial organizations could rent space to perform experiments.
- Observations of the earth and its atmosphere.
- A platform for space-based communications including the maintenance and upgrading of communication satellites.
- New materials developed in space for use on Earth or in space.

The space station will be the place for industry to operate pilot plants and to gain experience working in space. There are at least three major areas of commercial activity that could have

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substantial economic, technical and political payoffs:

1. **Telecommunications.** The further advancement of telecommunications will require deployment of large multi-mission satellites with power requirements in the megawatt range. User costs could be lowered by extending satellite life with on-orbit maintenance and repair performed by the space station crew. The space station could be a control center for satellite transmission, and a relay and switching network. It could be the base for assembling and launching platforms with multi-purpose communication functions. This will reduce crowding of satellites in the most valuable piece of real estate – geosynchronous orbit.

The space station could be used to evaluate new technologies such as a 100-foot diameter multibeam antennas which would make a Dick Tracy wrist-watch-type global communication possible, and experiments on electromagnetic wave propagation for the development of new spectral windows, particularly important as frequency bands get crowded. (A subject hotly debated at past World Administration Radio Conferences.)

2. **Materials Processing in Space.** The absence of gravity in orbit has potential implications for the science and technology of material processing. Scientists believe that new knowledge could be gained and that unique or improved products could be produced in the space environment for use both on Earth and in space.

The influence of gravity on most physical phenomena is well established. With rare exceptions, it is insignificant at the atomic and molecular levels. However, the already well-known consequences of low gravity on phenomena occurring in solids, liquids and gases could lead to economically significant, innovative products. The following are the major advantages of material processing in space:

- Buoyancy-driven natural convection is reduced or nearly eliminated for substantial periods of time.
- Large samples can be levitated and isolated for containerless processing.
- The gravity-induced separation of mixtures of materials with different densities is reduced or nearly eliminated.
- Containment structures can be used that would not survive on Earth.
- Basic assumptions about theoretical models of sys-

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tems in which complicated patterns of fluid density variation are inherent can be tested.

- Molecular-level forces in microscopic systems can be studies.

Although the scientific benefits of material processing in space are increasingly recognized, the commercial benefits of material processing will have to be demonstrated in future space shuttle experiments to guide manufacturing activities associated with a space station. At present, the most promising commercial application of material processing in space include pharmaceuticals, electronic material, glasses, metal, alloys and composites. Material processing in space will not only advance science, but demonstrate that materials with unique and valuable properties can be produced. This will stimulate the development of new terrestrial production methods and also lead to a future space-based material processing industry.

An important role for a space station in material processing will be as a national R&D laboratory. This will provide the opportunity for industry to explore the potential of material processing in space for commercial production and to close the information gap between the United States and the Soviet Union resulting from their more than 1,500 material experiments compared to less than 100 of ours.

3. **Services.** Industry could provide services to a space station in the way services are provided to terrestrial industrial facilities. Examples of such services are power supplies, housekeeping and life support, food service systems and waste management, medical and health care, rent or sale of standard modules that may be attached to a space station structure and on-orbit refueling facilities for orbital payload transfer systems. The Startrek Food Supply Company, Celestial Palace Hotel and the Orbital Power and Light Company are not yet traded on the stock exchange but they could be the growth stocks of tomorrow!

Japanese industry is interested in the possibility of utility services which could permit Japan to move into the forefront of space technology. Japan's Space Energetics and Environment Laboratory has emerged as a potentially important Japanese contribution to the space station program. The purpose of this laboratory is to undertake experiments aimed at improving technology for the generation and transmission of energy in space and from space to Earth. The laboratory is an ambitious

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project which could give Japan a commanding lead in technologies pertaining to energy generation and transmission.

The permanently manned space station will have an important role in support of a broad range of scientific and commercial activities, which may be performed either in the space station or in a free-flying satellite tended by the space station. The station will permit extensive facilities in orbit to be built up gradually and equipment to be maintained and repaired leading to major improvements in capabilities to perform scientific investigations, to manufacture products and to reduce project costs. It could be a support base for transportation of payloads to higher Earth orbits and eventually provide routine access to the moon and to the planets. The building of a lunar base, where materials could be processed for use in the construction of more extensive space projects in Earth orbits and in support of scientific explorations,would provide a major mission for the space station. This base would give an open-ended aspect to the development and growth of an industrial infrastructure that could support an increasing variety of commercial activities designed to make the most effective use of the inexhaustible energy and material resources of the solar system. The space station is "The Right Stuff" to ensure that U.S. industry will be in a position to meet the competition from other nations in exploiting the opportunities for commercial activities in space.

A Look to the Future

Space activities could be expected to evolve exponentially as knowledge is gained, new markets are opened up and international cooperation as well as competition in space becomes accepted. Complex political, social, legal and financial challenges will have to be met on a national and international scale to assure that the tangible returns of space commercialization will be of increasing befefit and to reward those who have pioneered in the creation of new space industries.

Future economic payoffs from the commercialization of space can only be projected in broad outline. Assumptions about the development of commercial activities have led to projections of substantial markets and potential revenues; however, even if annual revenues fail to increase as rapidly as projected, the market potential is so large that space industries could be among the fastest growing industrial activities in the next century.

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Conclusion

Humanity's progress, with increasing technical sophistication, raises hopes that the challenges of the future will be met without adverse effects and with widespread and growing benefits to society. This progress has been hard earned because it has occurred in response to unanticipated crises.

The significant progress that has been made as a result of broadly-based technical, economic, environmental, and societal studies on the SPS is resulting in the growing consensus that the SPS is one of the promising power-generation options which could contribute to meeting global energy demands in the 21st century. Its successful implementation, together with energy conservation measures and solar energy applications on Earth, could lead to the elimination of energy-related concerns. The SPS could provide not only the impetus for peaceful cooperation among nations, but help this civilization to achieve the inevitable transition to renewable sources of energy.

Pursuit of the SPS goals represents an approach to the development of space technology for commercial purposes, one of which is to tap the inexhaustible energy resources of space. This is in consonance with C.P. Snow's admonition: "It is only by the rational use of technology – to control and guide what technology is doing – that we can keep any hopes of a social life more desirable than our own: or in fact of a social life which is not too appalling to imagine."(8)

It is time to take a positive view of the achievable economic returns from space endeavors. We must recognize the constructive and catalytic role that space commerce can play in sustaining the technological and economic competitiveness of those sectors of industry that form part of the emerging global economy. Strategic planning by the public and private sectors should begin now, to ensure that space will play an increasingly important role in humanity's continuing evolution. As J.D. Bernal observed in his essay from which we quoted at the beginning of this article: "We are on the point of being able to see the effects of our actions and their probable consequences in the future; we hold the future still timidly but perceive it for the first time as a function of our actions and their probable consequences in the future."(9)

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FOOTNOTES

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SPACE STATION PLANNING 1984

By Robert F. Freitag

1.0 Introduction

A process is underway in the United States to achieve the next major step for its Space Program; that is, the development and deployment of a permanently manned Space Station. A positive decision will set the course for space activities for the next two decades not only for the United States, but also for other countries and organizations that could become involved in the program.

The National Aeronautics and Space Administration (NASA) has received firm direction from the U.S. President for a strong, national space program. In his State of the Union Message on January 25, 1984, President Reagan said:

> "We can follow our dreams to distant stars, living and working in space for peaceful, economic, and scientific gain. Tonight I am directing NASA to develop a permanently manned Space Station and to do it within a decade.
>
> "A Space Station will permit quantum leaps in our research in science, communications and in metals and life-saving medicines which can be manufactured in space. We want our friends to help us meet these challenges and share in the benefits. NASA will invite other countries to participate so we can strengthen peace, build prosperity, and expand freedom for all who share our goals."

2.0 Background

Even before the Apollo Program had successfully landed a man on the moon and returned him safely to Earth, NASA engineers and scientists were considering the next step of the space age. That next step was defined to be the simultaneous development of two complementary capabilities. One was a safe, reliable transportation system that could provide routine access to space. The other was an orbital Space Station where humans could work and live in space and be the base camp from which other, more advanced "next steps" could be initi-

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ated. This thinking set the stage for two of the most significant activities carried out by NASA in the 1970s and 1980s; that is, Skylab and the Space Shuttle.

On May 14, 1973, the United States launched its first Space Station, Skylab, aboard a Saturn V booster. Skylab demonstrated that humans could function in space for periods up to 12 weeks and, with proper exercise, could return to earth with no ill effects. In particular, the flight of Skylab proved that man could operate very effectively in the weightless environment and that it was not necessary to provide artificial gravity to live and work in space. Skylab crews accomplished a wide range of emergency repairs on station equipment including freeing a stuck solar array panel, replacing rate gyros, and repairing a malfunctioning antenna. The crews twice installed portable sun shields to replace one lost during Skylab's launch. These activities clearly demonstrated the utility of man in space.

Another product of the Skylab program was NASA's realization that extravehicular activity (EVA) or spacewalk could be considered normal and routine. Skylab amassed more than 82 hours of EVA. Skylab also demonstrated the effectiveness of a scientific laboratory orbiting the Earth. Skylab's eight different solar telescopes provided a quantum step in our understanding of the sun. Materials processing experiments done aboard Skylab produced unusually high quality crystals of key microelectronic materials. Skylab-generated, Earth resources photography demonstrated the practicality of using space to observe the Earth with sensors tuned to visible, infrared, and microwave regions of the spectum. Skylab allowed a comprehensive series of life sciences experiments that provided the basic data needed to design equipment and procedures for long-term living and working in space. In short, the Skylab Program was a resounding success and established a baseline of U.S. experience in the operational use of a Space Station.

Unfortunately, Skylab was not designed for permanent presence in space. It was not intended to be serviced on orbit although the Skylab crews were able to carry out certain repairs. Further, Skylab was not equipped to maintain its own orbit. The absence of this capability eventually caused its fiery demise. Finally, Skylab was not designed for evolutionary growth and, hence, was subject to rapid technological obsolescence. These shortcomings, as we shall see, are carefully accounted for in the current NASA planning for a permanent Space Station.

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While the U.S. was conducting the Skylab Program, the Soviets were embarking on a more ambitious endeavor. The Soviet Union launched its first space station, Salyut-1, in April, 1971. In the years since that launch, additional Salyut stations have been placed in orbit. The Soviet program is an aggressive and expanding manned space flight program combining Soviet military and civilian missions. The two most recent Salyuts, - 6 and -7, represent a second-generation version of the Space Station. Salyut-6 demonstrated the ability to refuel the station using the Progress logistics craft. Salyut-6 cosmonaut crews carried out mission stay-times of up to 211 days in space. Ten international crews were hosted representing the nations of Czechoslovakia, Poland, East Germany, Bulgaria, Hungary, Vietnam, Cuba, Mongolia, Romania, and France.

Clearly, the Salyut Space Program represents a long-term, methodical development of space capabilities that the Soviet Government considers worthwhile and in their national interest. Their program is obviously well financed and has involved dozens of high energy launches. The challenge of the Soviet space program in general and of the Salyut Program in particular is unmistakable.

In the early 1970s, the United States embarked on the develpment of a reusable launch vehicle, the Space Shuttle. The Shuttle has completed its orbital flight tests and was declared operational on July 4, 1982. Since then, the Orbital Columbia and its sistership, the Challenger, have completed four operational flights. The third Orbiter, Discovery, has been delivered to the Kennedy Space Center and is being readied for her maiden flight. The fifth operational flight, STS-9, carried the Spacelab mission which was designed and built by the European Space Agency. It was Europe's first major entry into a manned space flight program. The crew included a West German scientist, Dr. Ulf Merbold, and the Spacelab itself contained hardware and other equipment manufactured by several European firms.

With the Shuttle Transportation System operational, NASA, in response to President Reagan's directive of January 25, 1984, is embarking on a program "to develop a permanently manned Space Station and to do it within a decade." NASA, also at the direction of the President, is inviting its friends and allies to participate in this major effort. Such participation may range all the way from cooperative assistance in Space Station mis-

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sions to involvement in the development of the Space Station itself.

3.0 Why A Space Station Now?

A Space Station is essential to ensuring civil leadership in space for the United States during the 1990s. A permanent, U.S., manned Space Station is needed to maintain the continuity and focus of the U.S. space program and to present a continuing challenge to industry and government.

The functions of a Space Station are listed in Table 1. The basic need for a Space Station is associated with providing a permanent facility in orbit that is rich in power, has ample astronaut, scientist, and technician man-hours available, and provides large facilities to assemble, deploy, and operate very large spacecraft – spacecraft that are too large to be carried in the Space Shuttle Orbiter payload bay.

A prime purpose of a Space Station will be the establishment of a laboratory in orbit to capitalize on the unique environment of space, one of which is weightlessness (sometimes referred to as microgravity). The Space Station will be a base for upper stage and spacecraft deployment, servicing, and retrieval; allowing the concept of reusable upper stages and spacecraft to reduce costs just as the reusable Orbiter has reduced launch costs. In the future, the Space Station could allow the creation of immense spacecraft assembled in orbit from subassemblies or piece parts brought up by Orbiters, extremely large antennas, power generation equipment, large spacecraft for Earth departure expeditions, and large manufacturing plants.

The Space Station program will present challenges that will create technological advances in many disciplines leading to benefits in sectors of our society far removed from the space program. Early studies of the needs and mission requirements of a permanently manned Space Station in the 1990s indicate that we will require advances in such key areas as space suit capability, data management and processing, electrical power generation, storage and distribution, and thermal control systems design. The same contractors who will develop and supply these technologically advanced capabilities for a Space Station will soon be using those same advances in the development of consumer goods. We saw dramatic examples of technology spin-off as a result of the Apollo and Space Shuttle

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TABLE 1

FUNCTIONS OF A SPACE STATION

- ON-ORBIT LABORATORY
  - SCIENCE AND APPLICATIONS
  - TECHNOLOGY AND ADVANCED DEVELOPMENT
- PERMANENT OBSERVATORY(S)
- TRANSPORTATION NODE
- SERVICING FACILITY
  - FREE FLYERS
  - PLATFORMS
- COMMUNICATIONS AND DATA PROCESSING NODE
- MANUFACTURING FACILITY
- ASSEMBLY FACILITY
- STORAGE DEPOT

A SPACE STATION IS A MULTI-PURPOSE FACILITY

Programs. This can be expected to be repeated in the Space Station case.

4.0 Architecture

A Space Station concept includes a system of permanent, manned and unmanned elements in orbit communicating with ground support facilities. The concept also includes one or more unmanned, free-flying platforms dedicated to commercial or scientific activities orbiting near a manned base that would serve as a human habitat, utility core, laboratory, and orbital service station. The Shuttle Orbiter would carry the various station elements to orbit, help assemble the Space Station in orbit, and periodically return to the Space Station's manned element bringing supplies, fresh crews, and equipment. Transportation between the manned element and the free-flying platforms would be by a co-orbiting, unmanned space tug called an Orbital Maneuvering Vehicle (OMV) based at the manned element. Eventually, the manned element would be the operations base for an Orbital Transfer Vehicle (OTV), a high-energy, propulsive stage for transporting payloads to higher Earth orbits or outward into the solar system. This concept is shown in Figure 1.

It is not yet certain what this Space Station system will look like since no Space Station design now exists. However, NASA is currently establishing the criteria for it. NASA would very likely adopt an evolutionary approach; that is, a Space Station capable of growing and changing to fit developing needs. NASA would start with the design, development, test, and deployment of a small but useful Space Station capable of supporting a crew of six to eight in a low altitude, low inclination orbit. Figure 2 illustrates a few examples of candidate configurations for the Space Station. Certain common architectural features can be noted. The laboratory modules, habitats, serving bases, and other elements are all modules similar to the European Spacelab whose size is determined by the dimensions of the Orbiter payload bay. The Shuttle is the basic assembly and logistics vehicle.

5.0 Technology and Operational Needs for a Space Station

The Space Station development concept is based upon two radical approaches for spacecraft. One is that of evolving technology where systems can be replaced with advanced equip-

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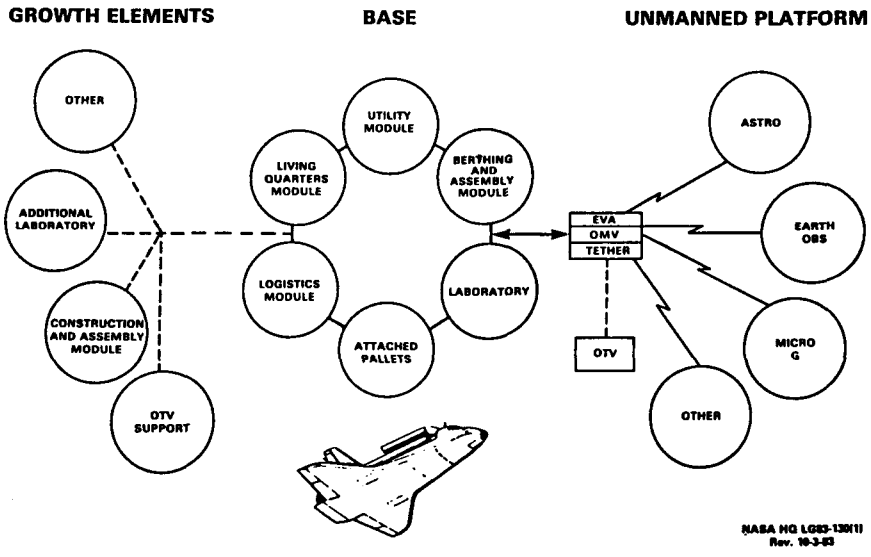
FIGURE 1

A SPACE STATION ARCHITECTURE: CLUSTER CONCEPT



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ment as new technologies emerge. The second is the design for maintainability and refurbishment. These concepts should reduce developmental and operational costs, greatly enhance reliability, and obviate obsolescence.

NASA is carefully assessing the technology requirements for a Space Station. Technology disciplines include data management, power, thermal, propulsion, and human capabilities. NASA is developing a plan to move technology from its current level to that required by an evolving Space Station that will allow upgrading as technology matures.

Through these planning processes, numerous technology issues have been identified. The challenge will be to optimize the Space Station design so that the right level of autonomy in space operations and the proper level of maintainability is achieved while still providing for evolving technology. The proper use and balance of automation and human capabilities will assure that the utility of the Space Station is brought to a level that can serve all user needs. The design, construction, and evolution of the Space Station must also assure low life cycle costs.

The use of dedicated systems such as Apollo can no longer serve our future purposes. Our planning must embrace the principles of reusability and maintainability yet provide technical flexibility to accommodate future requirements.

6.0 Status of U.S. Planning for a Space Station

NASA's Space Station planning effort has been underway for almost two years. Many long-standing international partners have participated in these planning activities. This planning is consistent with President Reagan's policy "to continue to explore requirements, operational concepts, and technology associated with permanent space facilities." The planning guidelines are divided into management and engineering-related categories as shown in Table 2.

The management-related guidelines include a comprehensive definition effort of approximately three years with an investment of 5 to 10 percent of the total program costs. The mission roles and responsibilities of the various NASA Centers will be determined early this year. NASA is also conducting the necessary preparation and planning to support definition studies with industry in 1985. It is anticipated that several contracts will be

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TABLE 2
SPACE STATION PLANNING GUIDELINES

MANAGEMENT RELATED

- Three year extensive definition (5-10% of program cost)
- NASA-wide participation
- Development funding in FY 1987
- IOC: early 1990's
- Cost of initial capability: $8.0B
- Extensive user involvement
  - Science and applications
  - Technology
  - Commercial
- International participation

ENGINEERING RELATED

- Continuously habitable
- Shuttle dependent
- Manned and unmanned elements
- Evolutionary
- Maintainable/restorable
- Operationally autonomous
- Customer friendly
- Technology transparent

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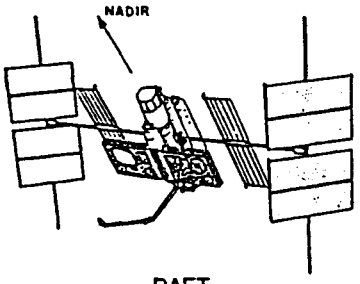
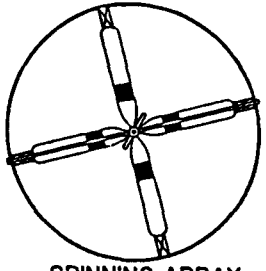
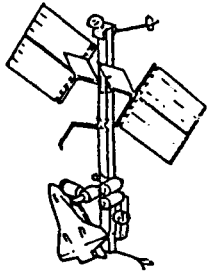
FIGURE 2
CANDIDATE SPACE STATION CONFIGURATIONS



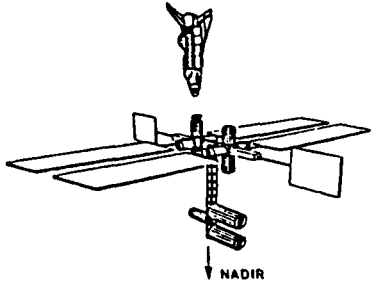
RAFT



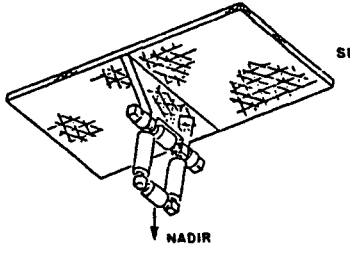
SPINNING ARRAY



POWER TOWER



CDG I



STREAMLINE

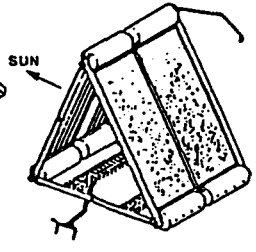


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FIGURE 3

SPACE STATION
INITIAL

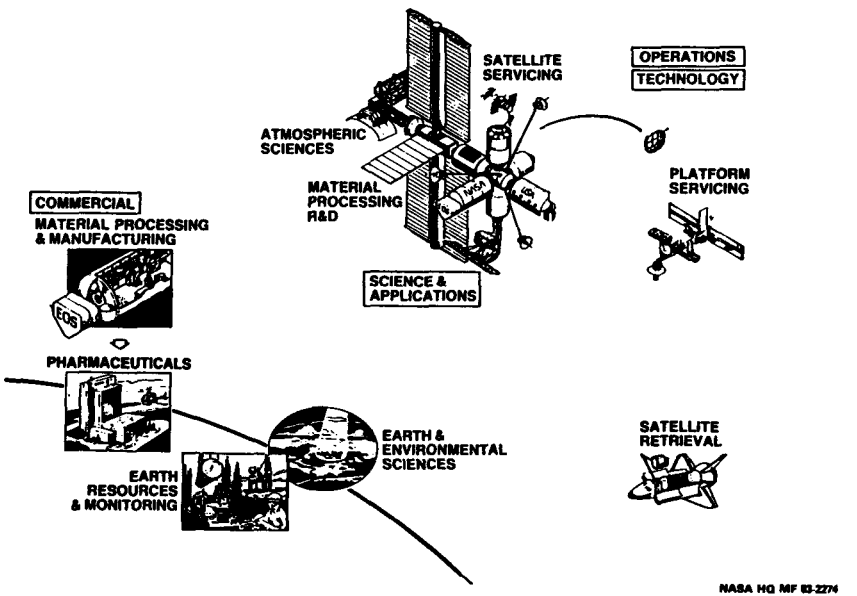

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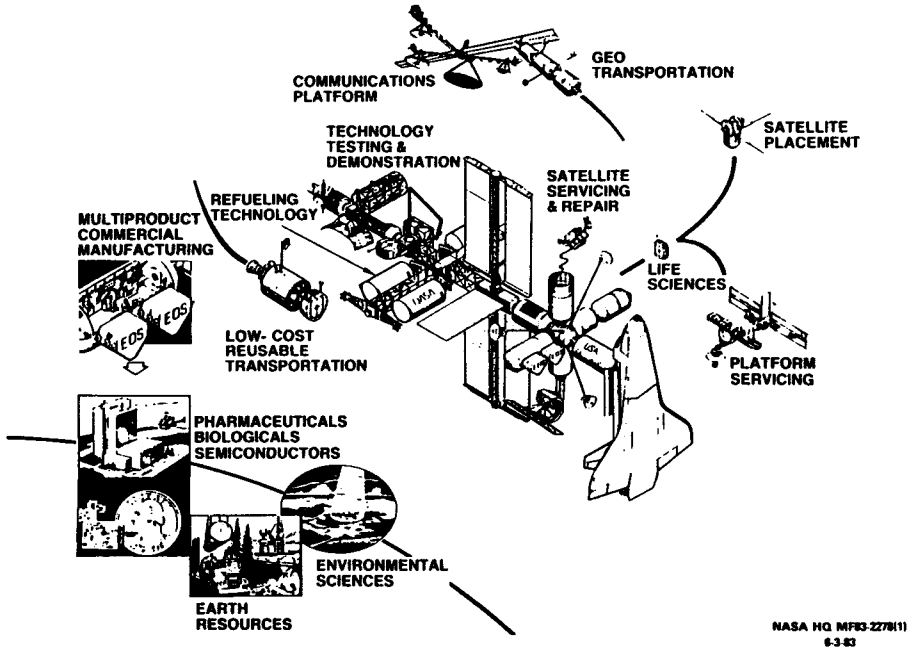
FIGURE 4

SPACE STATION

FUTURE



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let for different elements of the Space Station. Two or more contractors will conduct definition studies on the same element tasks. The program is also being planned so that significant design and development funding would start in Fiscal Year 1987 with a planned initial operating capability (IOC) in orbit early in the 1990s. The cost of the initial capability is estimated to be $8 billion.

The engineering guidelines include provisions for continuous habitation, Shuttle support for initial launch, resupply, and crew rotation, evolutionary growth through maintainable and restorable systems, manned and unmanned elements, and autonomous operation with the ability to upgrade systems as new technology becomes available. The entire system would be designed with emphasis on specific user needs.

An initial Space Station concept is shown in Figure 3. It would satisfy initial user requirements by providing utilitarian laboratories for science and applications including commercial and defense applications complete with servicing, logistics, and operations support. It may also include special payload platforms and the capability to service them.

The initial capability is planned to evolve with emerging technology and advanced developments into the Space Station of the 2000s and beyond. A futuristic concept is shown in Figure 4. It illustrates added capabilities to take payloads into higher orbits, service and repair satellites, retrieve various payloads, refuel vehicles, and many other capabilities to satisfy science and commercial needs.

7.0 Utilization of a Space Station

User requirements, which translate into functional capabilities, provide the foundation for the development of the Space Station architecture. The Space Station has focused on studies which emphasize user requirements for three groups: 1) Science and applications; 2) commercial; and 3) technology development. Study contracts recently conducted by eight U.S. aerospace contractors assessed these requirements. The results of the study contracts were integrated into a single, time-phased mission set for a significant number of missions. These are illustrated by discipline in Table 3.

On the basis of this mission set and the associated functional capabilities required of the Space Station system, the "first cut"

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TABLE 3

SPACE STATION DEFINITION PRELIMINARY MISSION DATA BASE (1991-2000)

- Initial Data Base
- Derived from Shuttle and ELV Base
- Will Change as Station Capabilities Become Better Understood and Mission Priorities Shift
- Not the List of Mission/Payloads the Station Will Fly in the early 1990's

SCIENCE AND APPLICATIONS
- Astrophysics
- Earth Science and Applications
- Solar System Exploration
- Life Sciences
- Materials Science
- Communications

COMMERCIAL
- Materials Processing in Space
- Earth and Oceans Observations
- Communications

TECHNOLOGY DEVELOPMENT
- Materials and Structures
- Energy Conversion
- Computer Science and Electronics
- Propulsion
- Controls and Human Factors
- Space Station Systems/Operations
- Fluid and Thermal Physics

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at Space Station capabilities has been developed and is shown in Table 4. These capabilities satisfy all initial requirements with the inclusion of two unmanned platforms, one co-orbiting with the manned Space Station and one in a near polar orbit. It should be noted that the future system requires 160 kilowatts (KW) of power to the user as well as the space-based Orbital Transfer Vehicle (OTV) for the transportation node function. As in the initial Space Station, materials processing facilities are the power drivers.

8.0 Commercialization of Space

The Space Station concept of today encompasses many new and broader spacecraft capabilities than were possible a decade ago. In addition to the science and applications laboratory functions, today's concept includes promising commercial opportunities. Commercial opportunities in space are defined as those products, processes, and services which demonstrate technical, economic, and institutional viability sufficient to achieve private sector investment in, ownership of, and operation of the activity as a profit-making venture.

The first 25 years of the Space Age has seen very significant programs of commercial utilization of space systems for profitable enterprise. The dramatic achievements of the communications industry's exploration of geostationary satellites are well known. In the 1960s, NASA undertook the development of the first communications satellites. Since that time, a vast, multinational business has emerged based on the idea of providing long distance communications services on Earth through exploitation of the global capabilities of communications satellites in synchronous equatorial Earth orbits. The tax revenues collected by the U.S. government each year from the corporations involved in this very profitable, space-based business exceed the total early NASA investment in communications satellites. A similar success story can be recited for the NASA investment in meteorological satellites whose daily space-based photography has become a part of the nightly television weather report. The U.S. Navy's TRANSIT navigation satellite is also a great commercial success with shipboard systems installed on over 4,000 ships flying the flags of fifty nations. Even more significant is that these shipboard systems are manufactured by about fifteen nations. Similar steps are beginning for the commercialization

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TABLE 4
SPACE STATION: EARLY CUT AT CAPABILITIES

	INITIAL	FUTURE
BASE AT 28.5°		
Crew	6—8	12—18
Power	75KW	160KW
Attached payloads	Some	More
Servicing capability	Initial (close by)	Mature
Smart front-end TMS	Available	Available
Data system	300 MBPS	300 MBPS
Utility module	One	More
Laboratory module	One	More
Logistics module	Two	More
Living quarters module	One	More
Multi-berthing adapter	One	Under study
PLATFORMS		
28.5°/15KW	One	Several
Polar/15KW	One	One
SPACE-BASED OTV	No	Yes
MANNED POLAR STATION	No	Under study

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of Earth observations systems such as the U.S. LANDSAT, the French SPOT system, and the German MOMS equipment. Likewise, the provision of launch servies, initially government subsidized, are moving into commercialized operations with upper stages, launch boosters, and spacecraft being furnished by private industry.

NASA has met with receptive firms in various industries to introduce the attributes of space and to start dialogues. These discussions have stimulated forward-looking industrial managers, planners, and research leaders to conceptualize activities that can lead to profitable ventures in space. NASA would then provide assistance and access to space technology with a view toward early proof of concept, typically in NASA low-gravity facilities such as drop tubes and towers, airplane flights and, in some cases, Shuttle flights. This program has begun to stimulate innovative thinking in firms in a number of fields (e.g., crystal growth, biological separations, containerless processing of alloys and other materials, and production of optical glass). The focus is on processes that gain a special advantage from the space environment and on products with high market value.

Two examples of commercial ventures are the McDonnell Douglas-Johnson and Johnson ventures and the Microgravity Research Associates ventures. McDonnell Douglas, using its own risk capital, is experimenting with a continuous-flow electrophoresis system in space that is capable of yielding 700 times the quantity of certain kinds of pharmaceuticals with five times the purity than what can be produced on Earth. Their maket potential is enormous.

Microgravity Research Associates (MRA) is a small, risk capital firm that will use its own funds to design and build an electroepitaxial furnace to produce gallium arsenide crystals which are virtually free of defects and are of very high purity for use in electronics and computer applications. MRA believes that this kind of gallium arsenide crystal can be produced only in the microgravity of space. This material could potentially replace silicon as the microelectronic chip material of the future.

The Space Station which NASA now contemplates will, on a long-term basis, accommodate many of the commercial process and product applications now being studied by industry. It fosters further activity by enabling the development of space technology and operational techniques in fields such as space

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construction, Earth and space observation and monitoring, satellite servicing, testing, transportation node operation, and human endurance studies.

The commercialization of space in all its forms will have increasing implications for the U.S. economy, security, and world leadership and prestige. We have observed the value to Japan's economy gained through government and industry partnerships. Space offers one of several opportunities for government to demonstrate leadership and support to industry. There is a challenge to both sectors to use vision, creativity, and perseverance to make such a partnership work.

9.0 Potential for International Participation

NASA has seen a tremendous interest in its Space Station planning activities by many of its long-standing, international cooperative partners. The growing space ambitions of the European Space Agency (ESA), Canada, Japan, France, Germany, and Italy have prompted these countries to conduct parallel mission analysis studies at their own initiative and expense. Results of some of these studies compared with United States requirements are shown in Table 5. Periodic meetings have been held to exchange study results. In addition, these countries are examining potential contributions to a Space Station if the opportunity to cooperate arises.

These early discussions are important for NASA and its potential partners. Since the Space Station is viewed as a working orbital facility, NASA is gaining information on potential world-wide Space Station utilization patterns. Given the scope and complexity of a Space Station, this early involvement has given NASA and the international community time to carefully evaluate cooperative possibilities.

NASA has a long, successful history of cooperative activities. It has undertaken numerous activities with the European Space Agency and with individual European countries. For example, NASA and British government agencies have participated in the Ariel Satellite Program. Five satellites were launched from 1962 to 1974 to investigate a broad spectrum of scientific questions in the radio sciences, particles and fields, and high-energy astronomy areas. Other cooperative activities include British hardware contributions to U.S. meteorological satellites, the NASA International Ultraviolet Explorer, and the Solar Maxi-

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TABLE 5

INTERNATIONAL SPACE UTILIZATION SUMMARY

MISSION AREA	U.S.	ESA	JAPAN	GANADA
MATERIAL SCIENCE AND SPACE PROCESSING				
MANNED R&D LAB	●	●	●	●
ATTACHED PROCESSING FACILITY	●			
CO-ORBITING PROCESSING FACILITY	●	●	●	●
LIFE SCIENCE				
MANNED R&D LAB	●	●	●	●
CO-ORBITING RES. FACILITY				
SPACE SCIENCES AND APPLICATIONS				
EARTH OBSERVATION				
HIGH INCL. FF/P	●	●		●
ATTACHED RES.	●			
MANNED HIGH INCL.			●	
ASTRONOMICAL OBSERVATION				
ATTACHED OBS.	●			
LOW INCL. FF/P	●	●	●	●
HIGH INCL. FF/P	●	●	●	●
TECHNOLOGY AND OPERATIONS				
LARGE STRUCTURES	●	●	●	●
ENERGETICS	●	●	●	●
SENSOR DEVELOPMENT	●			●
MAINTENANCE/SERVICE/REPAIR	●	●	●	●
OTV	●	●		●

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mum Mission. More recently, the United Kingdom and the Netherlands participated in the Infrared Astronomical Satellite (IRAS), by providing the ground operations systems and an experimental instrument on the spacecraft. As we have all recently heard, IRAS has made some outstanding discoveries which astronomers will be studying for years. Finally, the United Kingdom is participating in the International Satellite-aided Search and Rescue Program which has already demonstrated its ability to save lives. In the field of space commercialization, several United Kingdom contractors have made successful, profitable arrangements with international industrial partners in the fields of communications satellites.

Europe became a partner with NASA in its Shuttle Program by building Spacelab. The recent launch of Spacelab aboard STS-9 marked the culmination of many years of hard work and excellent cooperation and is only the beginning of the possibilities Spacelab provides. Spacelab offers numerous opportunities in several commercial areas and in the fields of science and applications, materials processing, and communications.

These joint activities have benefitted all of us because we have been able to share the costs of these undertakings, thus allowing us to do more work. Very importantly, the scientific results from these activities have been shared among us.

It is our belief that large, peaceful, joint high-technology programs among nations hold the hope of vitalizing high-technology industry on both sides of the ocean and strengthening our commercial and political ties. The only such program in sight now and for the immediate future is the Space Station program.

10.0 Conclusion

The United States must continue space research, development, and applications in order to reap societal benefits and maintain space leadership. This continued involvement, shared with other nations and in cooperation with commercial companies, will expand the world's space activities into new realms. Just as we have shifted from pure space research and exploration in the 1960s toward applications in the 1970s and the routine operations in the 1980s, space activities in the 1990s and into the next millennium will take on new meaning to mankind.

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Just as NASA had no idea that the Apollo Program would spin-off so many societal benefits in the 1980s, NASA cannot fully predict the societal impact and benefits of the Space Station in the year 2000. What is known is that the U.S. and many countries now have both a taste for space-borne knowledge and the institutional mechanism for utilizing new knowledge and rapidly converting it to new applications that come in many forms.

The "high road" to space will soon be travelled by the common man, not just by those who possess "the right stuff." When the Space Station passes from the esoteric concepts of 1983 to the mundane activities of 2001, with factories in orbit, with permanent laboratories routinely yielding new knowledge, and with payload launches from the Space Station to the Moon, Mars, and other orbits in between and beyond, mankind will have found its place in the universe and will no longer be restricted to the world under its feet. We will then have the start of "A City In Space."

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BOOK REVIEW

A DEFENSE THAT DEFENDS: BLOCKING NUCLEAR ATTACK

by Lt. General Daniel O. Graham, U.S. Army (Ret.) and Gregory A. Fossedal, with introduction by Richard V. Allen
Devin-Adair, Old Greenwich, Connecticut, 1984

"Books offering vital, fundamental, and truly revolutionary ideas are seldom accepted at face value, and are often disregarded by those who rule the world of books. But here we deal with a book that quite literally deserves our undivided attention, because it addresses the question of the nation's survival, and shows how...we can reverse the relentless pressures to rely solely on weapons of mass destruction."

With that statement Richard V. Allen, Distinguished Fellow of the Heritage Foundation and former national security advisor to President Reagan, begins his introduction to a new hardcover book *A Defense That Defends: Blocking Nuclear Attack,* published in March by Devin-Adair. Co-authored by Lt. Gen. Daniel O. Graham and Gregory A. Fossedal, a Wall Street Journal editorial writer, the new book sets forth, in Allen's words, "a comprehensive analysis of the strategy, economics, technology and politics of defending the U.S. and its allies against nuclear attack."

It is also a matured and powerful restatement of the space-based strategy initially proposed with release of the High Frontier study in March 1982, and adopted in principle as national policy in President Reagan's historic nationwide television address of March 23, 1983. *A Defense That Defends* offers furthermore a timely update and projection of the advance of the High Frontier idea during a year in which it rose to the status of a major national issue and fended off successfully a broad range of attacks by defenders of the status quo in defense policy.

Anticipating rapid acceleration of the national strategic debate, the authors recall the "breathtaking" public response to the President's March 23, 1983, commitment to defense which brought the "largest and more positive flood of letters and calls" any Reagan speech to that date. They note

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wryly that under MAD, hawkish Pentagon generals and nuclear freeze advocates start alike from the same assumption that Soviet leadership will remain rational and not risk nuclear destruction of its people, but point out that the MAD doctrine is rational *only* if defense is in truth impossible – an assumption only the U.S., but never the Soviets, have subscribed to.

Graham and Fossedal sketch the series of ad hoc decisions by which U.S. policymakers drifted, largely unbeknown to the public, into the "no defense" posture that has prevailed for the past dozen years. They show in alarming detail – some only recently revealed – how the Soviets have engaged in the most massive arms buildup in history during those same years, while U.S. defense expenditures, expressed as a share of the GNP, fell steadily from a 10.2% average in the mid-1950s to only 5.1% in 1977-80 as more than one defense-minded president was compelled by circumstances to curtail his programs. They note that President Reagan's initial proposal for a "massive" defense build-up had shrunk as early as 1982 to a figure only negligibly larger than President Carter's five-year projection.

Pondering reasons why the proposals of several previous presidents including John F. Kennedy had first stirred public enthusiasm, then rapidly subsided into the MAD routine, Graham and Fossedal predict that "these gains will prove illusory for all future presidents so long as the change in strategy from all offense to defense remains only a hazy idea to be carried out in the event of miraculous technological breakthrough."

True defense of our people, they contend, is tied inexorably to genuine military reform: "Only a military program that proceeds efficiently can sustain public backing." At the heart of the problem is an acquisition system which now requires 13 to 15 years to obtain new weapons which formerly could be brought from adoption to deployment in six years. The selection and politicized manufacture of "boondoggle, gold-plated" weapons, the stretching-out of schedules with resultant cost increases of 30% a year, force each president to accept most of the strategic assumptions of his predecessors and to conclude that no new strategy could even become effective while he is in office.

A Defense That Defends commands the most serious study of the citizen-analyst in its concluding chapters which, besides designating imperative weapon-acquisition reforms, call for a new and postive foreign policy that includes ground- and

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space-based defense against nuclear missiles. Closing with terse, incisive answers to all major points raised by critics who have bestirred themselves in defense of the MAD policy-complex, the book demonstrates clearly just how rapidly the High Frontier idea has moved toward center stage in the national debate. For these and other reasons, *A Defense That Defends* is must reading for thoughtful skeptics and especially for High Frontier partisans, who will find much ammunition in the book's four appendices which include a list of the Soviet Union's multitude of violations of the ABM and SALT treaties.

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E.L. Howe, the guest editor and principal compiler of this issue, is an author and circuit lecturer who entered academia after careers in journalism and as an executive of two major airlines at New York. He served as a U.S. naval combat intelligence officer in the Pacific (in WW II and the Korean War) and at the Pentagon; **Steven Adragna** is Chairman of the Conference on the Atlantic Community, affiliated with Georgetown University; **Fred Charles Iklé**, Undersecretary of Defense for Policy in the Reagan administration, once headed the Social Science Department at the University of Chicago and taught political science at MIT. Formerly affiliated with the Rand Corporation and the Harvard Center for International Affairs, he served as director of the U.S. Arms Control and Disarmanent Agency from 1973-1977; **Edwin F. Black**, Brig. Gen., U.S.A. (Ret.) is an authority on nuclear strategy who served many years in Southeast Asia and is currently chairman of the Hawaii chapter of the Council on Foreign Relations; **Thomas H. Krebs**, formerly the senior Pentagon Soviet space analyst, performed the first operational warfare analyses on current and projected Soviet space programs. He is the author of "The Capability to Control Space: A New Space Doctrine," and is currently a Washington-based defense consultant; **Robert Bussard**, president of the Energy Resources Group, Inc., has been engaged in developing advanced power and weapons systems for over 35 years, and has served on numerous government panels since the late 1950s. He holds an M.S. in Engineering from UCLA and a Ph.D. in Physics from Princeton University; **Daniel O. Graham**, Lt. Gen. U.S.A. (Ret) was formerly director of the Defense Intelligence Agency., and is currently Project Director of High Frontier. He is the author of several books, including "A Defense That Defends: Blocking Nuclear Attack"; **S.W.B. Menaul**, Air Vice-Marshal, Royal Air Force (Ret.), former Director of Bomber Operation in the Air Ministry, Commander of the British Atomic Task Force, and Chief of Staff of the Bomber Command, is currently Vice President of the London-based Foreign Affairs Research Institute; **J.L. Janssen van Raay**, an attorney by profession, is a Dutch member of the European Parliament; **Robert C. Richardson III**, Brig. Gen. U.S.A.F. (Ret.), is a co-founder and deputy director of High Frontier; **Peter E. Glaser** is Vice President of Arthur D. Little Co., Inc., and a preeminent authority on the commercial and economic implications of space age research; **Robert F. Frietag** is Deputy Director of NASA Space Station Task Force.

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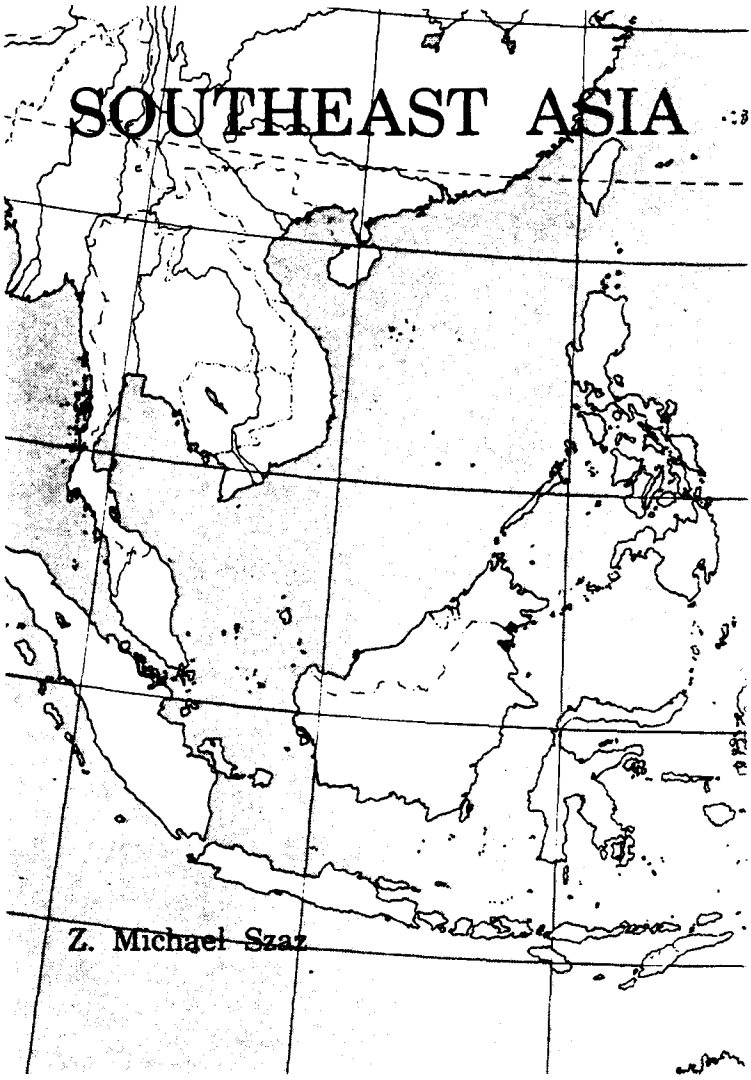

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